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User's Manual for STRIPE: A Computer Code for Simulating Striped Bass Young-of-the-Year Population in the Hudson River

A. H. Eraslan
R. D. Sharp
W. Van Winkle

ENVIRONMENTAL SCIENCES DIVISION
Publication No. 1646

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Task: Methods to Assess Impacts on Hudson River Striped Bass

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

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ABSTRACT

The structure and operational features of the main program and subroutines of the STRIPE computer code are described. All the necessary information and instructions are presented for implementing the computer code in simulating the daily variations and the longitudinal distributions of the various life stages of the young-of-the-year striped bass population in the Hudson River. Complete samples of input data and output results are given for 1973 conditions.

FOREWORD

The STRIPE computer simulation model was used in the final environmental statement for Indian Point Nuclear Generating Plant, Unit No. 3.[1] A detailed explanation of the theory and equations used in the STRIPE code appears as an appendix in this final environmental statement and in a separate, special report to the U.S. Nuclear Regulatory Commission.[2]

SUMMARY

This report presents the structure and operational features of the STRIPE computer code. It includes all the necessary information and instructions for implementing the computer code in simulating the daily variations and longitudinal distributions of the various life stages of the striped-bass young-of-the-year population in the Hudson River.

The computer code can be used either with simple input data or with detailed input data for the geomorphic-physiologic characteristics of the channel and the temporal and longitudinal variations of the flow, temperature, and salinity conditions in the estuary.

The input data for the various life stages (e.g., egg, yolk-sac larva, post-yolk-sac larva, Juvenile I, Juvenile II, and Juvenile III) includes the durations of the life stages based on information from the literature and from sampling programs in the estuary. The input data also include apparent natural survival probabilities and timewise continuous coefficients for growth and mortality rates. To incorporate various levels of biological compensation, the input data also include specified factors which can separately vary the apparent survival probabilities, growth rate coefficients, and mortality rate coefficients of each life stage as functions of the population density of that life stage. These three life stage biological characteristics are formulated as functions of temperature and salinity also.

The input data include the number of cross-section segments along the estuary (e.g., for 76 elements, each 2 miles in length, for the 152-mile length of the Hudson River). The geometrical properties of the elements (i.e., surface width, depth, area, volume) are determined internally in the computer code based on input data about the transect profiles of the estuary. Input data can be limited to only width and depth in applications which require only simple approximation of the geometrical properties.

The physical conditions in the river are determined based on input data for (1) amplitudes of tidal velocity in the elements, (2) daily freshwater flow rate at the upstream-end of the estuary (e.g., at Troy Dam), (3) water temperature in the elements, and (4) salinity in the elements. The input data for the physical conditions can also include specified longitudinal variations of the daily freshwater flow rates resulting from additional runoff along the estuary and the temporal variations of the temperature and salinity conditions. The input data can be limited to constant values for all four physical characteristics in applications which require only simple approximations for the physical conditions in the estuary.

The input data include values for the coefficients used in the formulation of the longitudinal tidal-dispersion transport in the estuary. The user can specify different values for the coefficients to approximate the observed tidal-dispersion transport of the different life-stages. Coefficients for specifying the convection-defect transport which results from the lateral and vertical density variations of the life stages also can be specified. The values for these coefficients can be determined based on parametric studies to obtain the best agreement between the trial results

of the computer simulations and the field-measured data. The input data can be limited to a constant, uniform, longitudinal tidal-dispersion coefficient without any convection-defect transport in applications which require only simple modeling of the overall longitudinal dispersion phenomenon in the estuary.

The input data include values for the coefficients used in the modeling of the migratory transport of the three juvenile life stages, based on a formulation that represents a balance between the effects of shoaling preference and overcrowding. The values for these coefficients can also be determined based on parametric studies to obtain the best agreement between the trial results of the computer simulations and the field-measured data. The coefficients can be specified as zeros in applications which do not require the consideration of migratory transport.

The input data also include coefficients for determining the rates of reduction of the life-stage populations by entrainment and impingement at the power plants based on (1) the differences between the population densities entering the intakes and the average densities in the main flow channel, (2) avoidance factors (for Juveniles) which consider temperature-dependent and salinity-dependent mobility characteristics, (3) geometric factors for the intake and discharge structures, and (4) temperature-dependent survival probabilities of the life stages upon passage through the cooling water system of power plants. If detailed information is not available for the entrainment and/or impingement conditions at a power plant, the user can eliminate the effect of any one of the four controlling factors by specifying either zero or 1 for the value of the coefficient associated with the formulation of the controlling factor.

The initial condition data can be specified either as (1) zero population densities for all the young-of-the-year life stages in all the elements, corresponding to conditions at the beginning of the spawning period, or (2) for restart computational runs, nonzero population densities for the young-of-the-year life stages in the elements, corresponding to longitudinal distributions in the estuary after the start of spawning.

The structure and the operational features of the MAIN program and all the SUBROUTINES are presented as abridged flow charts. The main computational steps in each subroutine are discussed to illustrate the operational features of the subroutine. Definitions of all the important FORTRAN variables, including all the ones in COMMON, are included in the appendix. The necessary instructions for preparing the input data about the flow conditions in the estuary and for the biological conditions of the striped-bass young-of-the-year life stages are also included.

The auxiliary capability of the STRIPE code for presenting the computer simulation results in printer plot format is discussed. Complete samples of input data and output results for the simulation of the striped bass young-of-the-year life-stage population distribution in the Hudson River for 1973 are also included.

Although the STRIPE code was developed specifically for computer simulations of the striped bass young-of-the-year population in the Hudson River, it can be utilized, with minor modifications, for simulating the life-stage populations of other aquatic organisms (planktonic and/or nektonic) in any river or estuary.

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SUMMARY OF THE COMPUTATIONAL EQUATIONS

The computational algorithm of the STRIPE computer code is based on a tidal-averaged, one-dimensional, discrete-element mathematical model for simulating the distribution of the population densities of the striped bass young-of-the-year life stages in tidal estuaries; the model is described in detail in Eraslan et al.[1] (1976) and U. S. Nuclear Regulatory Commission[2] (1975). This chapter is intended only to summarize the computational equations of the tidal-averaged transport model to help the user understand the special operational features of the STRIPE computer code.

Definitions of the Mathematical Variables of the Computational Equations

In the present formulation of the mathematical transport model, a one-dimensional discrete element "i" is defined as the control volume between two user-specified, transect cross sections as shown in Fig. 1.

Since the simulation model considers tidal-averaged, daily transient conditions in the estuary, all of the variables associated with the physical conditions and with the striped bass young-of-the-year populations are defined as being temporally averaged over the tidal cycle and spatially averaged over the volume of the discrete elements. In the subsequent definitions, the bar notation over a variable is employed to represent the temporally and spatially averaged property of that variable.

The geometrical properties of the discrete elements are as follows:

x_i = representative location of the discrete element "i" corresponding to the distance from the Troy Dam to the midpoint between its enclosure transects (ft),

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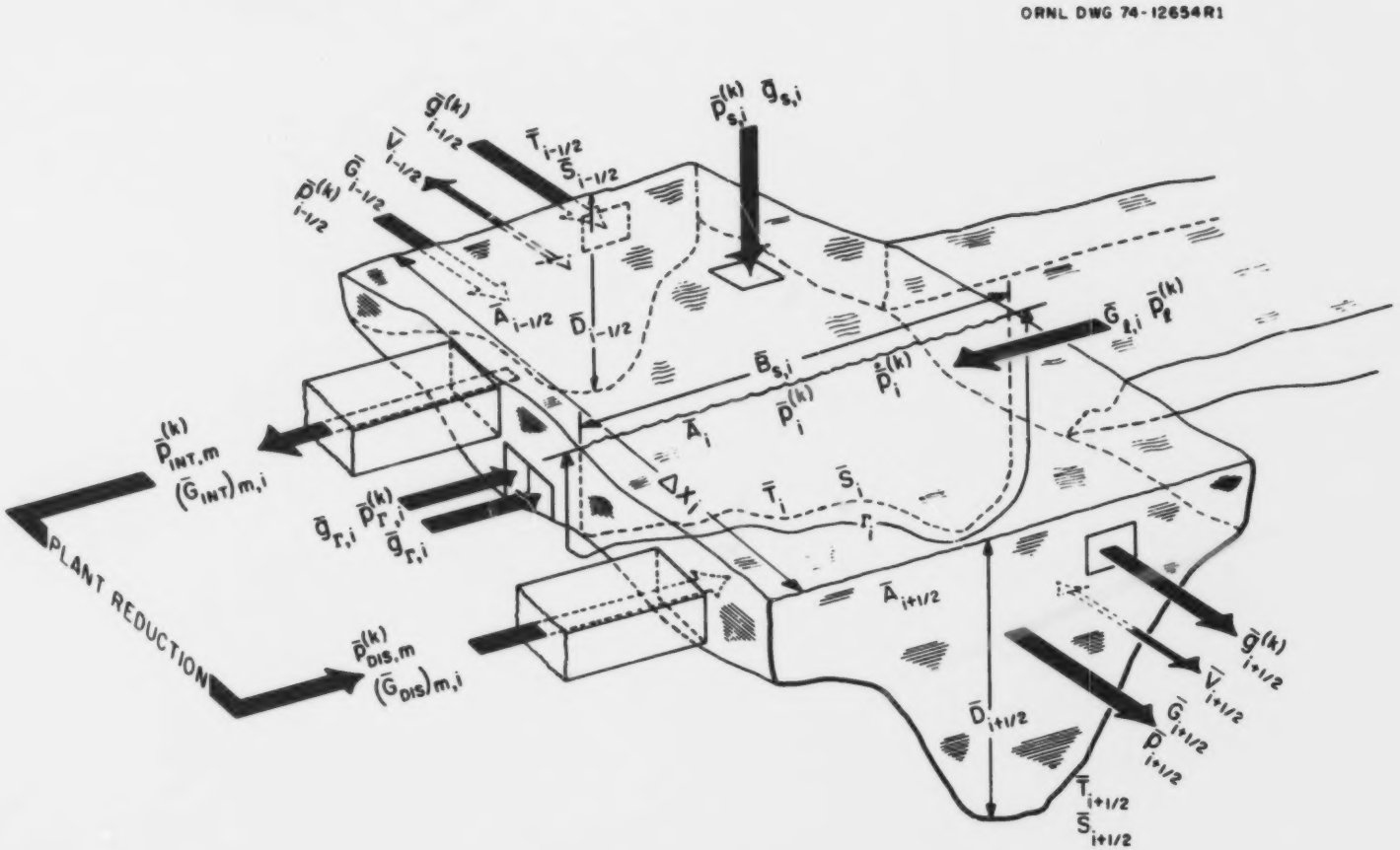

Fig. 1. Schematic representation of a discrete element for the conceptual development of the computer simulation model.

$x_{i\pm\frac{1}{2}}$ = locations of the upstream and downstream cross sections of discrete elements "i" (ft),

Δx_i = longitudinal length of discrete element "i" (ft),

$\bar{A}_i$ = average cross-sectional area of discrete element "i" (ft^2), (1)

$\bar{A}_{i\pm\frac{1}{2}}$ = average areas of the upstream and downstream cross sections of the discrete element "i" (ft^2),

$\bar{D}_i$ = average maximum depth in discrete element "i" (ft),

$\bar{D}_{i\pm\frac{1}{2}}$ = average maximum depths at the upstream and downstream cross sections of discrete element "i" (ft),

$\bar{B}_{s,i}$ = average surface width of the estuary in discrete element "i" (ft),

$\bar{\Gamma}_i$ = average length of the estuary bed contour in discrete element "i" (ft).

The variables associated with the flow conditions in the discrete elements are defined as:

$\bar{G}_i$ = net freshwater flow rate across the average cross-sectional area A_i of discrete element "i" (ft^3/hr),

$\bar{G}_{i\pm\frac{1}{2}}$ = net freshwater flow rates across the upstream and downstream cross-sectional areas of discrete element "i" (ft^3/hr),

$\bar{g}_{s,i}$ = flow rate per unit area (normal velocity component) on the estuary surface in discrete element "i" (e.g., rainfall) (ft/hr),

$\bar{g}_{\Gamma,i}$ = flow rate per unit area (normal velocity component) on the estuary bed contour in discrete element "i" (e.g., seepage, runoff) (ft/hr), (2)

$\bar{V}_i$ = maximum tidal speed in discrete element "i" (ft/hr),

$\bar{V}_{i\pm\frac{1}{2}}$ = maximum tidal speed at the upstream and downstream cross sections of discrete element "i" (ft/hr),

$\bar{G}_{l,i}$ = net nontidal flow rate into discrete element "i" from tributary "l" (ft^3/hr),

$(\bar{GINT})_{m,i}$ = net flow rate of the intake of power plant "m" in discrete element "i" (ft^3/hr),

$(\bar{GDIS})_{m,i}$ = net flow rate of the discharge of power plant "m" in discrete element "i" (ft^3/hr). (Note: the intake and discharge need not be in the same discrete element "i".)

The variables associated with the life-stage populations in the discrete elements are defined as:

$\bar{p}_i^{(k)}$ = population density of life stage "k" in discrete element "i" (number/ft^3),

$\bar{p}_{i\pm\frac{1}{2}}^{(k)}$ = population densities of life stage "k" at the upstream and downstream cross sections of discrete element "i" (number/ft^3),

$\dot{\bar{p}}_i^{(k)}$ = net local time rate of variation of population density (due to growth to the next life stage and mortality) of life stage "k" in discrete element "i" (number/ft^3/hr),

$\overset{-(k)}{P_{s,i}}$ = population density of life stage "k" in the surface flow $g_{s,i}$ in discrete element "i" (number/ft^3), (3)

$\overline{P}_{\Gamma,i}$ = population density of life stage "k" in the estuary bed flow $g_{\Gamma,i}$ in discrete element "i" (number/ft^3),

$\overset{-(k)}{P_{l}}$ = population density of life stage "k" in the tributary flow $G_{l,i}$ in discrete element "i" (number/ft^3),

$\overset{-(k)}{P_{INT,m}}$ = population density of life stage "k" in the intake flow $(GINT)_{m,i}$ in discrete element "i" (number/ft^3),

$\overset{-(k)}{P_{DIS,m}}$ = population density of life stage "k" in the discharge flow $(GDIS)_{m,i}$ in discrete element "i" (number/ft^3).

The flux terms associated with the general transport phenomena across the discrete-element, enclosure surfaces for the life-stage populations are defined as:

$\overset{-(k)}{g_{i\pm\frac{1}{2}}}$ = net transport flux of the population of life stage "k" across the upstream and downstream cross-sectional areas A of discrete element "i" (number/ft^2/hr), (4)

$\overset{-(k)}{g_{\Gamma,i}}$ = transport flux of the population of life stage "k" from the estuary bed contour surface into discrete element "i" (number/ft^2/hr).

The control parameters, which indicate the presence or absence of the additional transport effects in the discrete elements are defined as

$\delta_{l,i}$ = 1: tributary "l" in discrete element "i,"

0: tributary "l" not in discrete element "i."

$(\delta_{INT})_{m,i}$ = 1: intake of power plant "m" in discrete element "i,"

0: intake of power plant "m" not in discrete element "i." (5)

$(\delta_{DIS})_{m,i}$ = 1: discharge of power plant "m" in discrete element "i,"

0: discharge of power plant "m" not in discrete element "i."

In all of the definitions of the variables in Eqs. (1-4), the associated sign conventions are:

a. the positive x-axis is toward the Battery, originating at the Troy Dam;

b. all estuary flow rates are positive in the downstream direction, along the x-axis toward the Battery;

c. all geometric dimensions and areas associated with the discrete elements are positive;

d. all tidal speeds as magnitudes are positive;

e. all flow rates associated with the tributaries, intakes, and discharges are positive for inflow conditions into the discrete elements;

f. all flow rates per unit area (normal velocity components) are positive for inflow conditions into the discrete elements;

g. all transport fluxes for life-stage populations are positive along the downstream direction, along the x axis toward the Battery;

h. all population densities for all life stages are positive.

The governing equations of the simulation model can be developed in terms of the defined variables by applying the fundamental conservation principles to all the discrete elements that span the specified length of the estuary (Eraslan et al., 1976).[1]

Governing Discrete-Element Equation for the Population Densities of the Striped Bass Young-of-the-Year Life Stages

The development of the discrete-element form of the conservation of population numbers from the standard integral form does not lead directly to the required explicit form of the discrete-element equation for population densities. Application of the discrete-element method to the control volume integral for population number results in a combination of two time-derivative terms: (1) the required term for the time rate of change of population density, and (2) the term for the time rate of change of cross-sectional area (or water surface elevation), since the time rate of change of water volume also contributes to the net time rate of change of population number. To eliminate the term associated with the time rate of change of cross-sectional area, the product of the population density and of the discrete-element equation for the time rate of change of cross-sectional area is subtracted from the discrete-element form of the principle of conservation of population number (see Eraslan et al., 1976, for detailed development of the equation). Hence, the special development of the discrete-element form for population number leads to the final computational form which includes only the time rate of change of the population density in the discrete element. This new discrete-element form is uniquely different from the conventional conservative and nonconservative

discretized computational forms of the general transport equations, and it can be classified as an "intensive" form of the population density equation for the solution of the distribution of the population densities of the striped bass young-of-the-year life stages in an estuary.

The final computational form of the discrete-element equation for the population density of striped bass young-of-the-year life stage "k" in discrete element "i" becomes:

$$\frac{d\bar{p}_i^{(k)}}{dt} = \frac{s}{p_i}^{(k)} + \frac{1}{\Delta X_i \bar{A}_i}\{G_{i-\frac{1}{2}}[\bar{p}_{i-\frac{1}{2}}^{(k)} - \bar{p}_i^{(k)}] - \bar{G}_{i+\frac{1}{2}}[\bar{p}_{i+\frac{1}{2}}^{(k)} - \bar{p}_i^{(k)}]\}$$

$$+ \frac{1}{X_i \bar{A}_i}[\bar{A}_{i-\frac{1}{2}}\bar{g}_{i-\frac{1}{2}}^{(k)} - \bar{A}_{i+\frac{1}{2}}^{(k)}\bar{g}_{i+\frac{1}{2}}] + \frac{\delta_{1,i}}{\Delta X_i \bar{A}_i}\bar{G}_{1,J}[\bar{p}_{1,J}^{(k)} - \bar{p}_i^{(k)}] \qquad (6)$$

$$+ \frac{(\delta_{INT})_{m,i}}{\Delta X_i \bar{A}_i}(\bar{G}_{INT})_{m,i}[\bar{p}_{INT,m}^{(k)} - \bar{p}_i^{(k)}] + \frac{(\delta_{DIS})_{m,i}}{\Delta X_i \bar{A}_i}(\bar{G}_{DIS})_{m,i}[\bar{p}_{DIS,m}^{(k)} - \bar{p}_i^{(k)}]$$

$$+ \frac{\bar{B}_{s,i}}{A_i} g_{s,i}[\bar{p}_{s,i}^{(k)} - \bar{p}_i^{(k)}] + \frac{\bar{\Gamma}_i}{\bar{A}_i}\bar{g}_{\Gamma,i}[\bar{p}_{\Gamma,i}^{(k)} - \bar{p}_i^{(k)}] + \frac{\bar{\Gamma}_i}{\bar{A}_i}[\bar{g}_{\Gamma,i}^{(k)}] .$$

The left side of this equation represents the net time rate of change of the population density of life stage "k" in discrete element "i," and it is equal to the cumulative effect of the nine terms on the right-hand side of Eq. (6). Each term on the right side corresponds to the individual contribution of a physical or biological phenomenon that can control the time rate of change of population density of life stage "k" in discrete element "i." The nine terms on the right-hand side of Eq. (6) represent the following:

1. net local time rate of generation of population density of life stage "k" in discrete element "i," consisting of spawning rate, growth rate to next life stage, and mortality rate;
2. net difference in convective transport rates of population of life stage "k," consisting of the inflow convective transport rate [resulting from the population density difference between the population density at the upstream enclosure surface at "i-1/2" and the population density in the discrete element "i"] and the outflow convective transport rate [resulting from the population density difference between the population density at the downstream enclosure surface at "i+1/2" and the population density in the discrete element "i"];
3. net difference in the nonconvective transport rates of the population of life stage "k," consisting of the nonconvective transport rates (i.e., tidal dispersion transport rate, convection-defect transport rates, and migratory transport rate) at the upstream enclosure surface at "i-1/2" and at the downstream enclosure surface at "i+1/2," in discrete element "i;"
4. effect of the convective transport rate of life stage "k" associated with the flow of a stream (or tributary) "l," resulting from the population

density difference form) between the inflowing (or tributary) and discrete element "i;"

5. effect of the convective transport rate of life stage "k" associated with the intake flow of power plant "m," resulting from the population density difference between the intake flow (including the effects of the intake geometry factor and intake avoidance factor) and discrete element "i;"
6. effect of the convective transport rate of life stage "k" associated with the discharge flow of power plant "m," resulting from the population density difference between discharge flow (including the effects of probability of survival upon passage through power plant "m") and discrete element "i;"
7. effect of the convective transport rate of life stage "k" associated with surface flow rate (rainfall), resulting from the population density difference between surface flow (zero for rainfall) and discrete element "i;"
8. effect of the convective transport rate life stage "k" associated with estuary bed flow rate (groundwater seepage flow rate), resulting from the population density difference between the estuary bed flow and discrete element "i;"
9. nonconvective transport rate of life stage "k" at the estuary bed contour (bed of the main flow channel).

The last two terms, 8 and 9, are included in the discrete-element equation to enable the approximate incorporation of the population

transport effects in the vertical direction between the benthic layer (where there is no longitudinal transport) and the main flow channel of the estuary.

The computational algorithm of the STRIPE computer code simultaneously solves for the population densities of all of the striped bass young-of-the-year life stages, "k=1,...,K," in all the discrete elements, "i=1,...,N," by numerically integrating the intensive form of the discrete-element equation for the population density of the striped bass young-of-the-year life stage (Eq. 6).

Stability of the Numerical Solutions of the Computational Algorithm

The computational algorithm of the STRIPE code is based on the numerical solution of a semi-discrete system of moderately coupled, quasi-linear ordinary differential equations for the life-stage population densities in the elements. The mathematical system is numerically integrated by a fourth-order Runge-Kutta-Gill technique in order to guarantee accurate calculations of the effects of the net local time rates of variations of the population densities (due to spawning, growth to next life stage and mortality) of the life stages in the elements. Hence, the computational algorithm represents a multitime-step, explicit numerical solution method.

The formulation of the convective transport terms, along the curvilinear, longitudinal axis x of the estuary, based on second-upwind-differencing formulation (see Ref. 1) with specified flow conditions, requires that the time step of integration satisfy the Courant stability criterion in every element in the estuary, at all times during the computer

simulations. Hence, considering the element which has the critical conditions, the "necessary and conditionally sufficient" stability criterion for determining the maximum allowable time step for the numerical solution of the life-stage population density conditions becomes

$$\Delta t_{con} \leq \left[\frac{\Delta x_i}{|\bar{V}_i|}\right]_{min} = \left[\frac{\Delta x_i \; A_i}{|\bar{G}_i|}\right]_{min}, \tag{7}$$

where $\bar{V}_i$ represents the average freshwater flow velocity in the element. The necessary and conditionally sufficient stability criterion for determining the maximum allowable time step [Eq. (7)] does not include the effect of the unequal curvilinear lengths of the adjacent elements Δxi and $\Delta x_{i\pm1}$ on the stability of the numerical solution. Furthermore, it is difficult to determine the minimum conditions for the particular element which has the critical conditions in the estuary at every time step of the numerical integration. Hence, a more restrictive "necessary and sufficient" stability criterion, for determining the maximum allowable time step for the numerical solutions of the life-stage population densities, based on the numerical integration of the complete set of discrete-element-equations for the population densities of the striped bass young-of-the-year life stages [Eq. (3)], can be formulated as

$$\Delta t \leq \frac{(\Delta x_i)_{min} \; (\bar{A}_i)_{min}}{(R_{x;i,i\pm1})_{max} \; (|\bar{G}_i|)_{max}}, \tag{8}$$

where the maximum ratio of the curvilinear lengths of the adjacent elements Δx_i and Δx_{i+1} is defined as

$$(R_{x;i,i\pm1})_{max} = max\left[\left(\frac{\Delta x_i}{\Delta x_{i\pm1}}\right) or \left(\frac{\Delta x_{i\pm1}}{\Delta x_i}\right)\right] \quad . \tag{9}$$

The user can determine the maximum allowable time step of the numerical integration [Eq. (9)], by considering the specified input data to the STRIPE code, according to the following steps:

1. Determine $(\Delta x_i)_{min}$ as the smallest curvilinear longitudinal length (along the curvilinear longitudinal axis x of the estuary) among the curvilinear longitudinal lengths of all the elements (based on specified input data for geometrical conditions),
2. Determine $(\bar{A}_i)_{min}$ as the smallest cross-sectional area among the cross-sectional areas of all the elements (based on specified input data for geometrical conditions),
3. Determine the maximum ratio of the curvilinear lengths of the adjacent elements $(R_{x;i,i\pm1})_{max}$ by considering the ratios of the curvilinear lengths $\Delta x_{i-1}, \Delta x_i$ and Δx_{i+1} for three-elements at a time for all the elements (based on specified input data for geometrical conditions),
4. Determine the maximum absolute value of flow rate $|\bar{G}_i|_{max}$ as the maximum value of the freshwater flow rate that could occur in a particular element in the estuary at any time during the specified period of computer simulations (based on specified input data for temporarily varying freshwater flow conditions).

It is important to note that the minimum and maximum values for $(\Delta x_i)_{min}$ $(\bar{A}_i)_{min}$ $(R_{x;i,i+1})_{max}$ and $|\bar{G}_i|_{max}$ could (and generally do) correspond to different (more than one) elements along the estuary.

The "necessary and sufficient" stability criterion [Eq. (8)] guarantees the stability of the numerical solutions for the population densities of the striped bass young-of-the-year life stages based on considerations of the convective transport along the curvilinear longitudinal axis of the estuary with specified, tidal-averaged freshwater flow conditions. It does not guarantee the stability of the numerical solutions based on considerations of the local time rates of variations of the population densities of the life stages in the elements. The user must also consider the limitations on the maximum allowable time step of numerical integrations based on the convergence accuracy of the Runge-Kutta-Gill numerical integration technique with the local time rates of variations of the population densities of the life stages in the elements. However, in most applications, the time rates of variations of the population densities of the life stages are reasonably small; and hence, the "necessary and sufficient" stability criterion [Eq. (8)] usually determines the maximum allowable time step of the numerical integration used in the computer simulation of the young-of-the-year life-stage populations in the Hudson River.

SUBROUTINE DESCRIPTIONS AND FLOWCHARTS

A main program with ten subroutines constitutes the basis of the STRIPE package. These subroutines are called BIOCON, ENDCON, ESTCON, INITAL, OUTPUT, PLTCON, SOLFNC, SOLVER, TRBCON, and TRPORT. Three additional subroutines (STORER, DPLOTS, and TPLOTS) may be used to obtain extra output.

During a typical run of STRIPE, the program will enter three phases of operation. The phase entered depends on the value of variable KRUN. If KRUN = 0, initialization of parameters occurs in every subroutine except INITAL and the optional plotting subroutine, TPLOTS.

If KRUN = 1, the program is in its computational phase. During this time, the computer code progresses through the following steps:

1. Subroutine INITAL reads the time for the start of calculation (INYEAR,LEAPYR,IMONTH,IMNDAY,THRDAY), the initial spawned egg population (EGG(IX)), and population densities for every life stage in each discrete element (PDN(KP,IX)), where KP and IX are the indices for the life stage and discrete element, respectively.

2. MAIN starts the calculations at the initial time: (a) either at the beginning of the spawning period without any striped bass young-of-the-year in the river, or (b) at any other specified time with some nonzero PDN(KP,IX).

3. According to the input data, ESTCON determines the physical conditions (GFR(IX),TMP(IX),SLN(IX)) in each element in the estuary.

4. According to the input plant-operational conditions from PLTCON, ESTCON corrects the temperature distributions (TMP(IX)) based on the plant temperature rise values (DTMPLT(IX)).

5. ENDCON determines the life-stage population densities at the ends of the estuary.

6. According to the specified biological input parameters, BIOCON calculates the egg deposition rates (PRTEGG(IX)) in all the

elements and the survival percentage (CORSRV x COPSRV(KP)) and growth (PRTGRW(KP,IX)) and mortality rates (PRTMOR(KP,IX)) for every life stage in each discrete element.

7. According to the tidal dispersion coefficients on each enclosure surface IC(ETRTID(IC)), TRPORT calculates the transfer fluxes of life-stage populations across each transect due to tidal dispersion (PTRTID(KP,IC)).

8. TRPORT uses the transfer avoidance factor for each life stage (DVRPDN(KP)) to calculate the transfer fluxes of life-stage populations across each transect due to convective defect transport (PTRDEF(KP,IC)).

9. According to input biological characteristics (swimming speeds), shoal profiles of the estuary, and spatial density distributions, TRPORT calculates shoaling (PSCHOL) and crowding (PCROWD) factors that determine transport fluxes of life-stage populations across each transect due to migratory transport (PTRMIG(KP,IC)).

10. According to the specified net freshwater flow rates and based on the geometric properties of the elements and the life-stage population densities, SOLFNC calculates the net rates of convective transfer of life-stage populations into the specified elements (FNCCNV).

11. TRBCON determines the contributions to the life-stage population rates from tributaries (FNCPDN(KP,IXTRB)).

12. PLTCON calculates the net removal rates from the elements containing the intakes (FNCPDN(KP,IXINT)) and the net replenishment rates at the elements containing the discharge (FNCPDN(KP,IXDIS)) for the life-stage populations.

13. SOLFNC sums all the rates for the life-stage populations to determine the net time rate of change of each life-stage population in each element (FNCPDN(KP,IX)).

14. SOLVER determines the new life-stage population densities (PDN(KP,IX)) at the updated time T.

15. If the new time value (T) corresponds to a new day, OUTPUT prints (if IWRITE > 0) or plots (see APPENDIX B) the computed life-stage population densities depending on the output form specified. If the new time value does not correspond to a new day, steps 3-14 are repeated until NT time steps have been reached.

If KRUN = 2, written records and plots for the whole time period may be made by STORER and TPLOTS (see APPENDIX B). Restart cards for

a continuation of the present case may also be punched (if IPUNCH > 0). See APPENDIX A for a listing of the STRIPE program and a glossary describing the subroutines mentioned above, along with definitions of the important variables in the code. See APPENDIX B for a discussion and listing of the optional subroutines, STORER, DPLOTS, and TPLOTS. See APPENDIX C for the sample case data and results from the computer. A brief description of the operation of each routine follows. In addition, a flow chart summarizing the program flow through each routine except SOLVER is shown.

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MAIN (Fig. 2)

MAIN is the control routine of STRIPE. In this routine, control flag KRUN is set before every new phase of the program begins. For example, after KRUN is set to 0 (initial phase), calendar data for one year are read and initial calls are made to subroutines ESTCON, BIOCON, SOLVER, SOLFNC, ENDCON, TRPORT, TRBCON, and OUTPUT. Variable KRUN is then set to 1 (calculation phase), and subroutine INITAL is called for the initial conditions of the initial value problem. The number of time steps (NTOTHR) and the time step size (DTHR), along with the number of time steps between written output (NWRITE), are read in MAIN to define the period of simulation. ESTCON is called next to ensure that enough estuary data exist to span that period of simulation. Subroutine OUTPUT is called at this time to write the initial conditions.

By now MAIN is ready to drive the program through the simulation period (i.e., NTOTHR x DTHR total hours). During this time MAIN updates the time of calculation, calls subroutine PLTCON to get current plant conditions, calls subroutine ESTCON to get current estuary conditions, and calls subroutine SOLVER for the solution of the differential equations describing the problem. A check is then made to determine if it is time for written output (i.e., every NWRITE time steps). If it is time, subroutine OUTPUT is called. After the NTOTHR time steps, the calculation phase is complete and KRUN is set to 2 (special output phase). Subroutine OUTPUT is called, and, upon return from OUTPUT, the program execution is complete.

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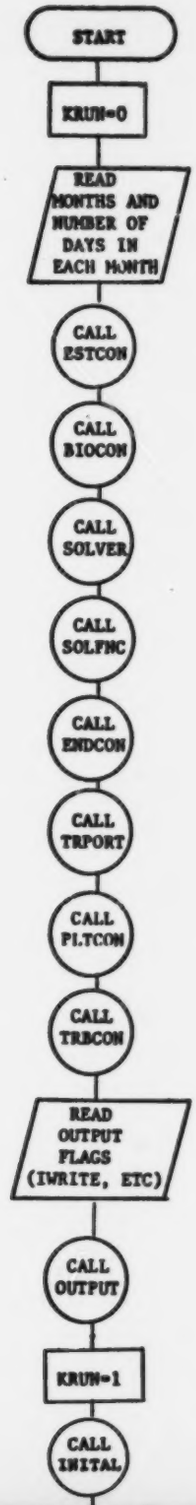

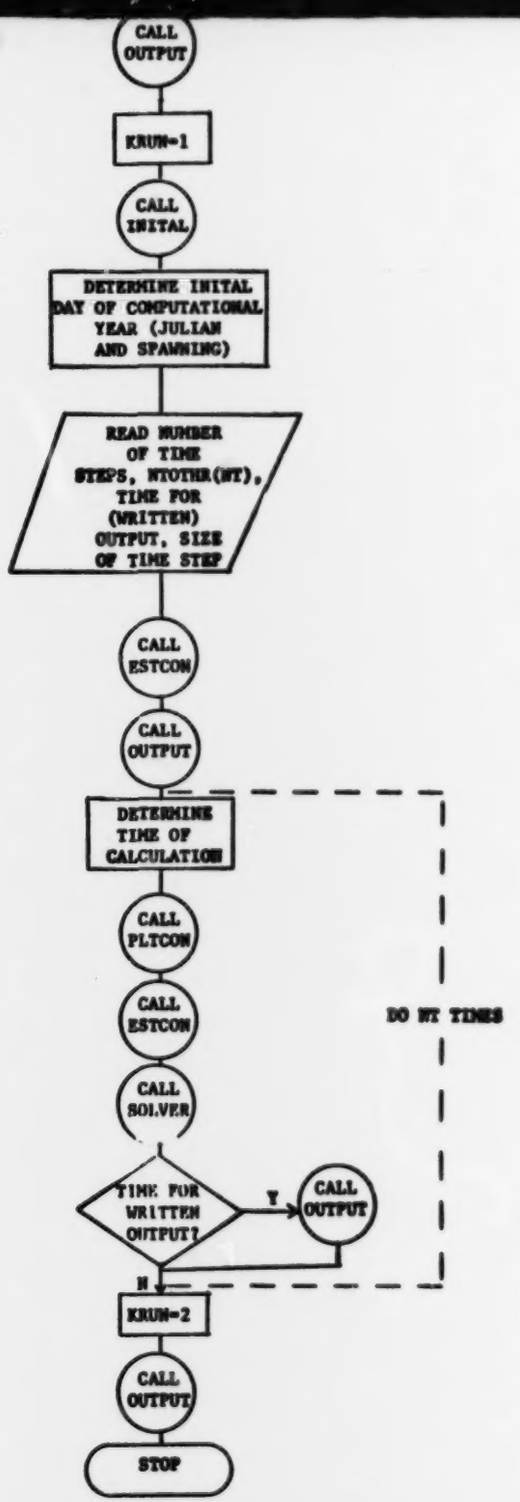

Fig. 2. Abridged flow chart of the main program.

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SOLFNC (Fig. 3)

Subroutine SOLFNC puts together the right-hand side of the initial value problems to be solved and returns the results to subroutine SOLVER to be solved. During the initialization phase (KRUN=0), the time-rate expressions to be integrated are initialized to zero. During the calculation phase (KRUN=1), subroutines ENDCON, BIOCON, and TRPORT are called to furnish components to the equations to be solved. In addition, subroutine TRBCON is called if the number of tributaries (NTRB) is greater than zero, and PLTCON is called if the number of operating plants (NPLANT) is greater than zero. Upon return from subroutine SOLVER, the life-stage population equations to be solved have been updated and are ready for solution.

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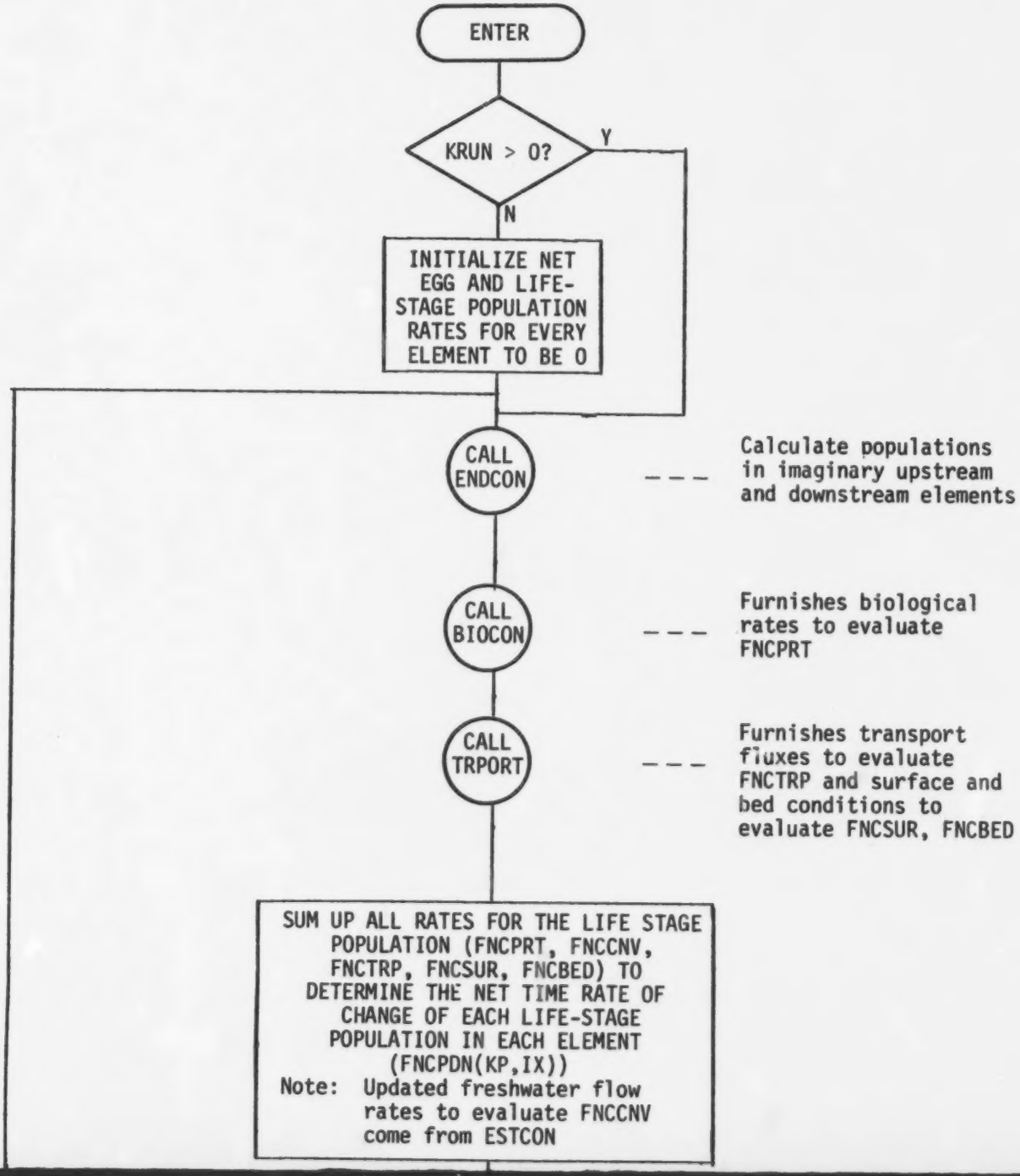
ENTER
KRUN > 0?
Y
N
INITIALIZE NET EGG AND LIFE-STAGE POPULATION RATES FOR EVERY ELEMENT TO BE 0
CALL ENDCON
Calculate populations in imaginary upstream and downstream elements
CALL BIOCON
Furnishes biological rates to evaluate FNCPRT
CALL TRPORT
Furnishes transport fluxes to evaluate FNCTRP and surface and bed conditions to evaluate FNCSUR, FNCBED
SUM UP ALL RATES FOR THE LIFE STAGE POPULATION (FNCPRT, FNCCNV, FNCTRP, FNCSUR, FNCBED) TO DETERMINE THE NET TIME RATE OF CHANGE OF EACH LIFE-STAGE POPULATION IN EACH ELEMENT (FNCPDN(KP,IX))
Note: Updated freshwater flow rates to evaluate FNCCNV come from ESTCON

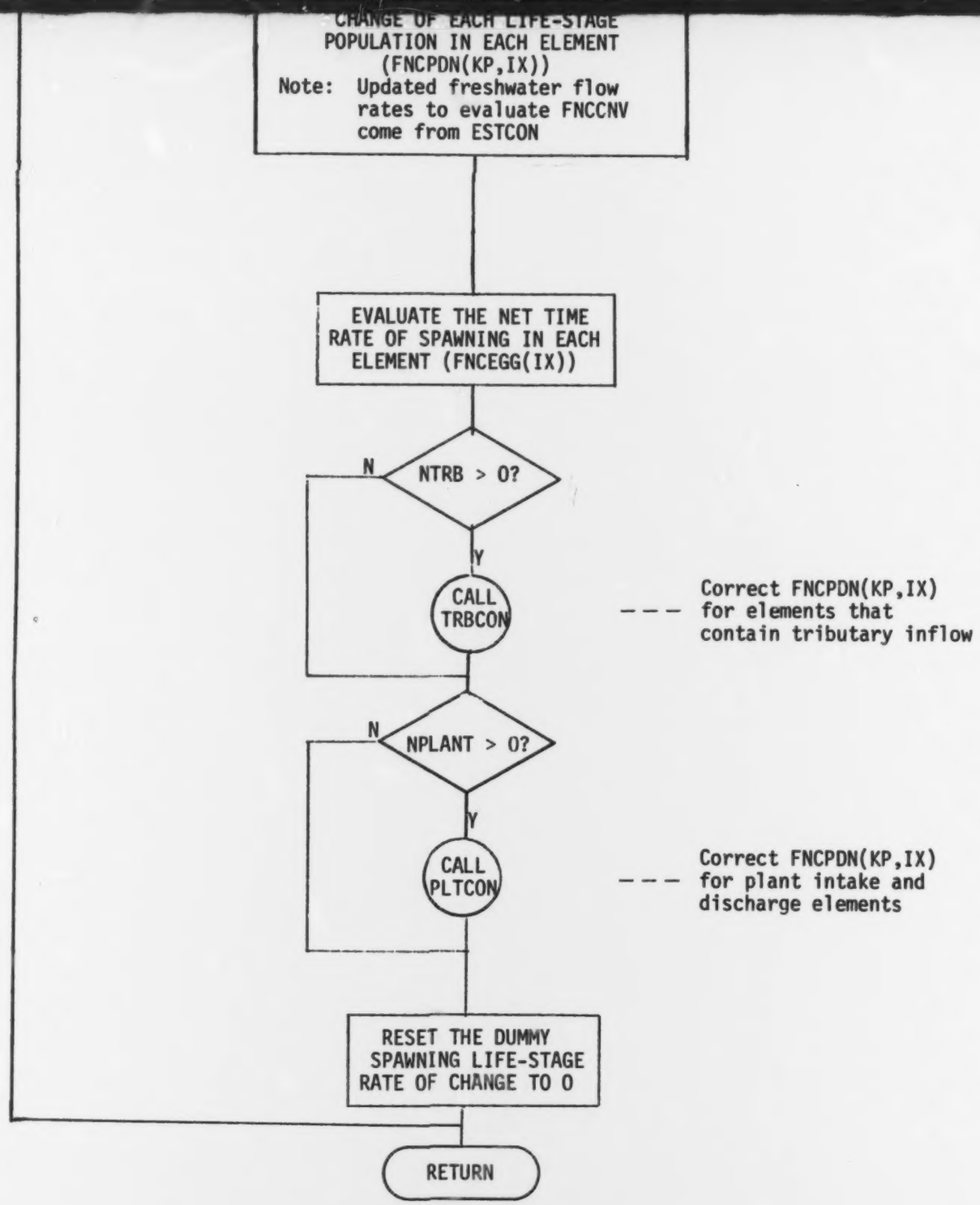

Fig. 3. Abridged flow chart of subroutine SOLFNC.

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ESTCON (Fig. 4)

Subroutine ESTCON furnishes the STRIPE program with the conditions in the estuary during the period of simulation. In the initial phase of STRIPE (i.e., KRUN=0), geometrical conditions and all flow, temperature, and salinity factors and other conditions that describe the characteristics of the estuary over time are read. During the first pass of the calculation phase (i.e., KRUN=1), ESTCON checks to make sure there are enough estuary data to describe the whole simulation period. If there are not enough data, an appropriate message is given and program execution is terminated. Otherwise, the program determines if the estuary data need to be updated and gives the appropriate action.

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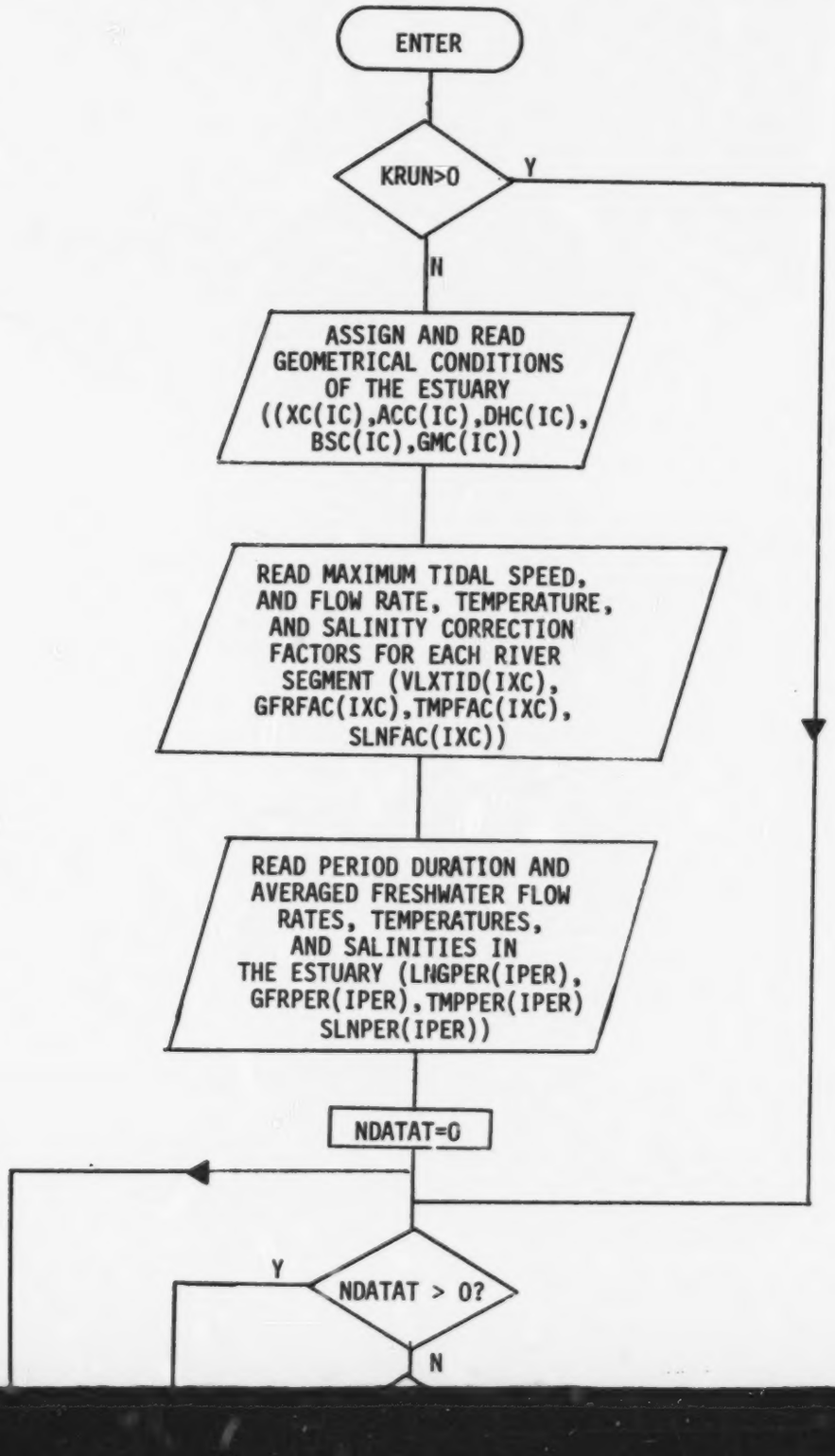
ENTER
KRUN>0
Y
N
ASSIGN AND READ GEOMETRICAL CONDITIONS OF THE ESTUARY ((XC(IC),ACC(IC),DHC(IC), BSC(IC),GMC(IC))
READ MAXIMUM TIDAL SPEED, AND FLOW RATE, TEMPERATURE, AND SALINITY CORRECTION FACTORS FOR EACH RIVER SEGMENT (VLXTID(IXC), GFRFAC(IXC),TMPFAC(IXC), SLNFAC(IXC))
READ PERIOD DURATION AND AVERAGED FRESHWATER FLOW RATES, TEMPERATURES, AND SALINITIES IN THE ESTUARY (LNGPER(IPER), GFRPER(IPER),TMPPER(IPER) SLNPER(IPER))
NDATAT=0
Y
NDATAT > 0?
N

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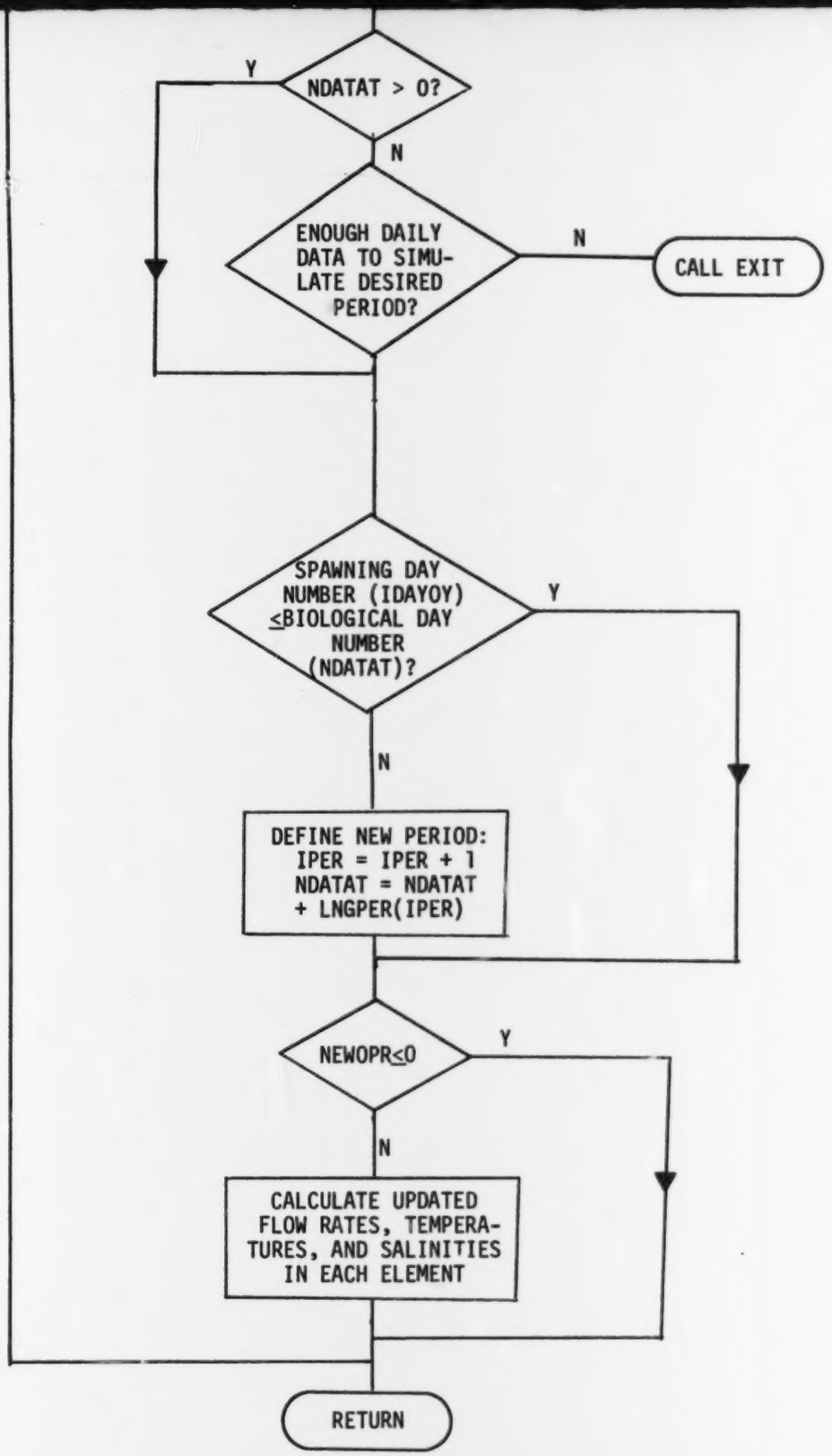

Fig. 4. Abridged flow chart of subroutine ESTCON.

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BIOCON (Fig. 5)

Subroutine BIOCON compares temperature and salinity characteristics for each life stage with temperature and salinity conditions in the estuary to determine correction factors for the growth and mortality functions for each life stage. BIOCON is like most of the other routines of STRIPE in that it is called once during the initialization phase (KRUN=0) and repeatedly during the calculation phase (KRUN=1) until the simulation is complete. In the initialization phase, all static and dynamic life-stage characteristics are defined before BIOCON returns to subroutine SOLFNC.

BIOCON uses biological control flags in three places in the calculation phase. The first check determines if the life stage can spawn by using variable IKPSPW. If the population cannot spawn, its spawning rate (PRTSPW) is set to zero. Otherwise, BIOCON uses the current conditions in a discrete element to calculate correction factors based upon population (CORPDN), temperature (CORTMP), and salinity, (CORSLN) for the overall calculation of PRTSPW. The density of the life stage is now checked. If the density is less than or equal to zero, the residual population density (PDNRES), the growth rate into the next life stage (PRTGRW), and the mortality rate (PRTMOR) are each set to zero before returning to SOLFNC. If the density is greater than zero, BIOCON determines CORPDN, CORTMP, and CORSLN to calculate the survival coefficient, CORSRV.

In a like manner, BIOCON then uses IKPGRW and IKPMOR, respectively, to calculate the coefficient for growth into the next life stage and the mortality coefficient. Next, the residual population density (PNDRES) is

determined, and the coefficients calculated previously are employed to determine PRTGRW and PRTMOR. The above sequence of calculations is performed for every life stage, KP, and every discrete element, IX.

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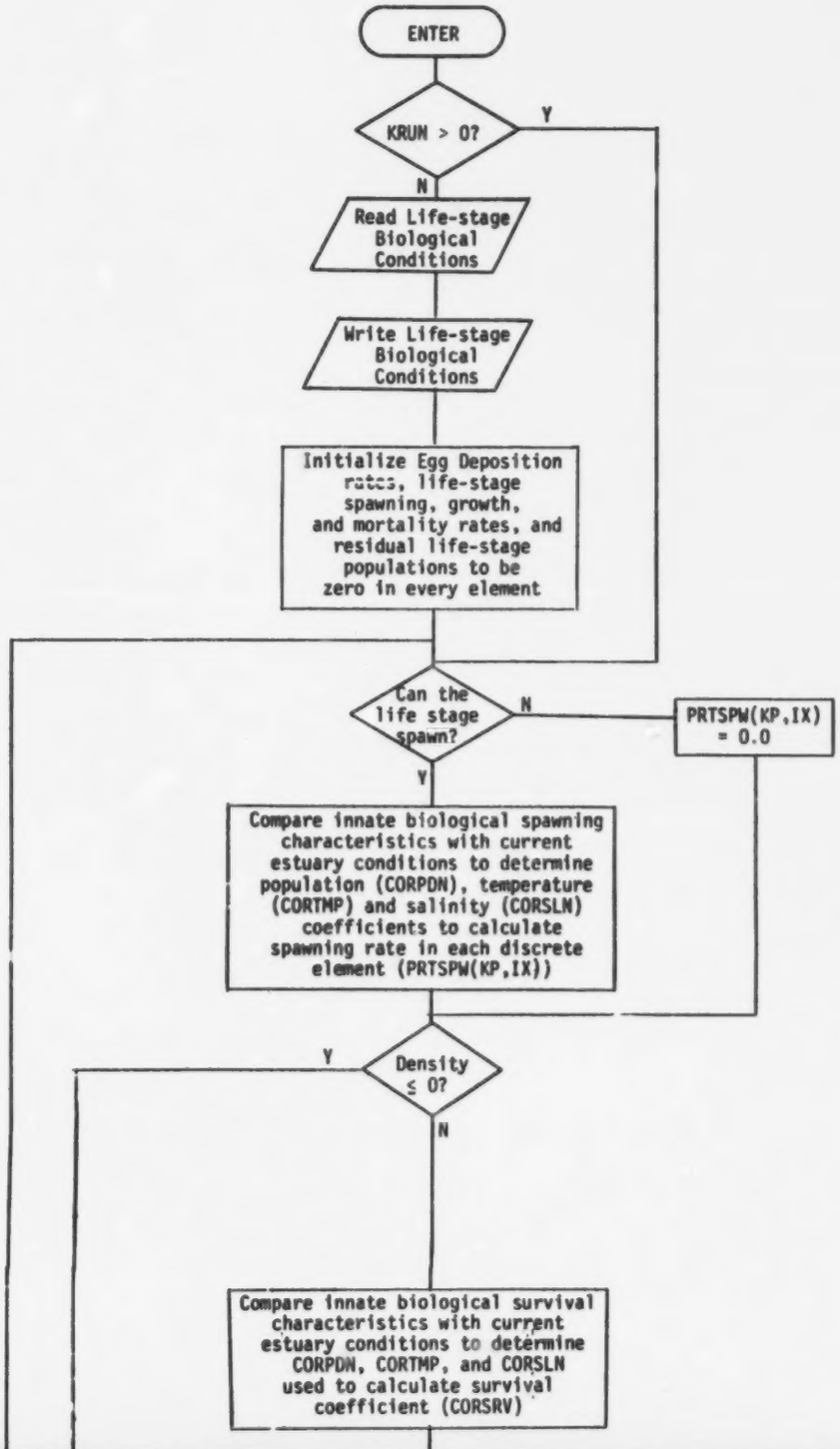
ENTER
KRUN > 0?
Y
N
Read Life-stage Biological Conditions
Write Life-stage Biological Conditions
Initialize Egg Deposition rates, life-stage spawning, growth, and mortality rates, and residual life-stage populations to be zero in every element
Can the life stage spawn?
N
PRTSPW(KP,IX) = 0.0
Y
Compare innate biological spawning characteristics with current estuary conditions to determine population (CORPDN), temperature (CORTMP) and salinity (CORSLN) coefficients to calculate spawning rate in each discrete element (PRTSPW(KP,IX))
Density ≤ 0?
Y
N
Compare innate biological survival characteristics with current estuary conditions to determine CORPDN, CORTMP, and CORSLN used to calculate survival coefficient (CORSRV)

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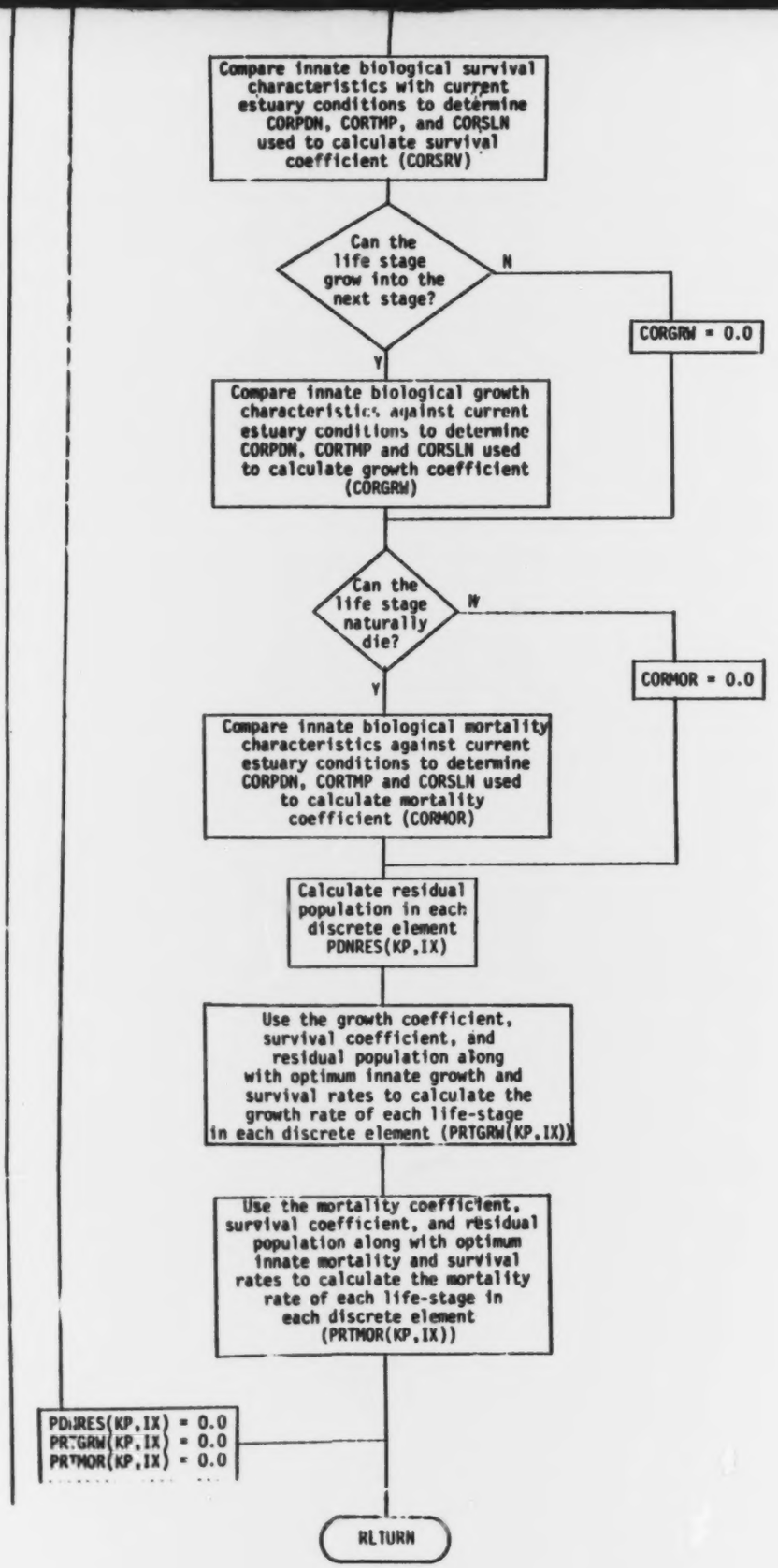
Compare innate biological survival characteristics with current estuary conditions to determine CORPDN, CORTMP, and CORSLN used to calculate survival coefficient (CORSRV)
Can the life stage grow into the next stage?
N
CORGRW = 0.0
Y
Compare innate biological growth characteristics against current estuary conditions to determine CORPDN, CORTMP and CORSLN used to calculate growth coefficient (CORGRW)
Can the life stage naturally die?
N
CORMOR = 0.0
Y
Compare innate biological mortality characteristics against current estuary conditions to determine CORPDN, CORTMP and CORSLN used to calculate mortality coefficient (CORMOR)
Calculate residual population in each discrete element PDNRES(KP,IX)
Use the growth coefficient, survival coefficient, and residual population along with optimum innate growth and survival rates to calculate the growth rate of each life-stage in each discrete element (PRTGRW(KP,IX))
Use the mortality coefficient, survival coefficient, and residual population along with optimum innate mortality and survival rates to calculate the mortality rate of each life-stage in each discrete element (PRTMOR(KP,IX))
PDNRES(KP,IX) = 0.0
PRTGRW(KP,IX) = 0.0
PRTMOR(KP,IX) = 0.0
RETURN

Fig. 5. Abridged flow chart of subroutine BIOCON.

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PLTCON (Fig. 6)

Subroutine PLTCON adjusts the net time rate of change of population density, FNCPDN(KP,IX), for life stage KP in discrete element IX, for those elements containing the intakes and discharges of operational power plants. In the initialization phase (KRUN=0), plant-related constants are defined and the temporal plant conditions and life-stage plant survival and avoidance characteristics are read and then written. In addition, the variable which includes the temperature rise from plant discharge for any discrete element IX, DTMPLT(IX), is initialized to zero along with the counter for days of plant operation (NPLDAY) and the new operation flag (NEWOPR).

PLTCON is called next in the calculation phase (KRUN=1). The subroutine argument (IPLFNC) is a control parameter that represents the number of power plants already operational at the current time. If IPLFNC is greater than zero, the program checks if the life stage is mobile. STRIPE then proceeds to calculate the corrected population change in the intake and discharge elements based upon a comparison of intake velocity and swimming speed.

On the other hand, if IPLFNC is not greater than zero, PLTCON checks NPLDAY to see if there have already been any plants operating. If not, the program checks to ensure that there are enough data to simulate the new operational period. If NPLDAY is greater than zero, the program checks to see if the parameters for new plant-operational period should be defined. If there is a new period, STRIPE first checks if there are any operational plants in the period. If there are none, DTMPLT is set to zero and PLTCON

returns to the calling program. Otherwise, PLTCON calculates DTMPLT and proceeds with mobility checks and corrections on the life-stage populations as before.

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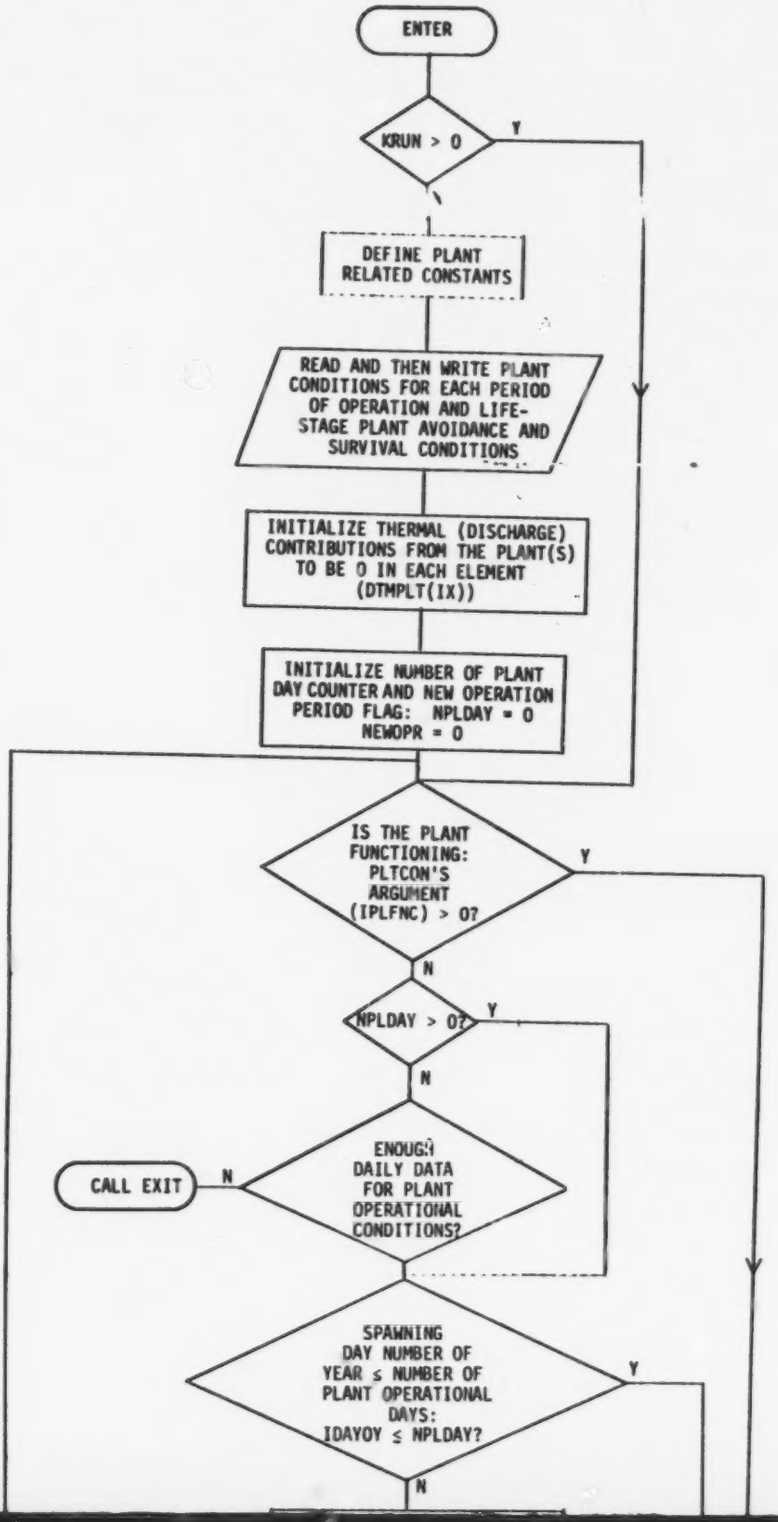
ENTER
KRUN > 0
Y
DEFINE PLANT RELATED CONSTANTS
READ AND THEN WRITE PLANT CONDITIONS FOR EACH PERIOD OF OPERATION AND LIFE-STAGE PLANT AVOIDANCE AND SURVIVAL CONDITIONS
INITIALIZE THERMAL (DISCHARGE) CONTRIBUTIONS FROM THE PLANT(S) TO BE 0 IN EACH ELEMENT (DTMPLT(IX))
INITIALIZE NUMBER OF PLANT DAY COUNTER AND NEW OPERATION PERIOD FLAG: NPLDAY = 0 NEWOPR = 0
IS THE PLANT FUNCTIONING: PLTCON'S ARGUMENT (IPLFNC) > 0?
Y
N
NPLDAY > 0?
Y
N
ENOUGH DAILY DATA FOR PLANT OPERATIONAL CONDITIONS?
N
CALL EXIT
SPAWNING DAY NUMBER OF YEAR ≤ NUMBER OF PLANT OPERATIONAL DAYS: IDAYOY ≤ NPLDAY?
Y
N

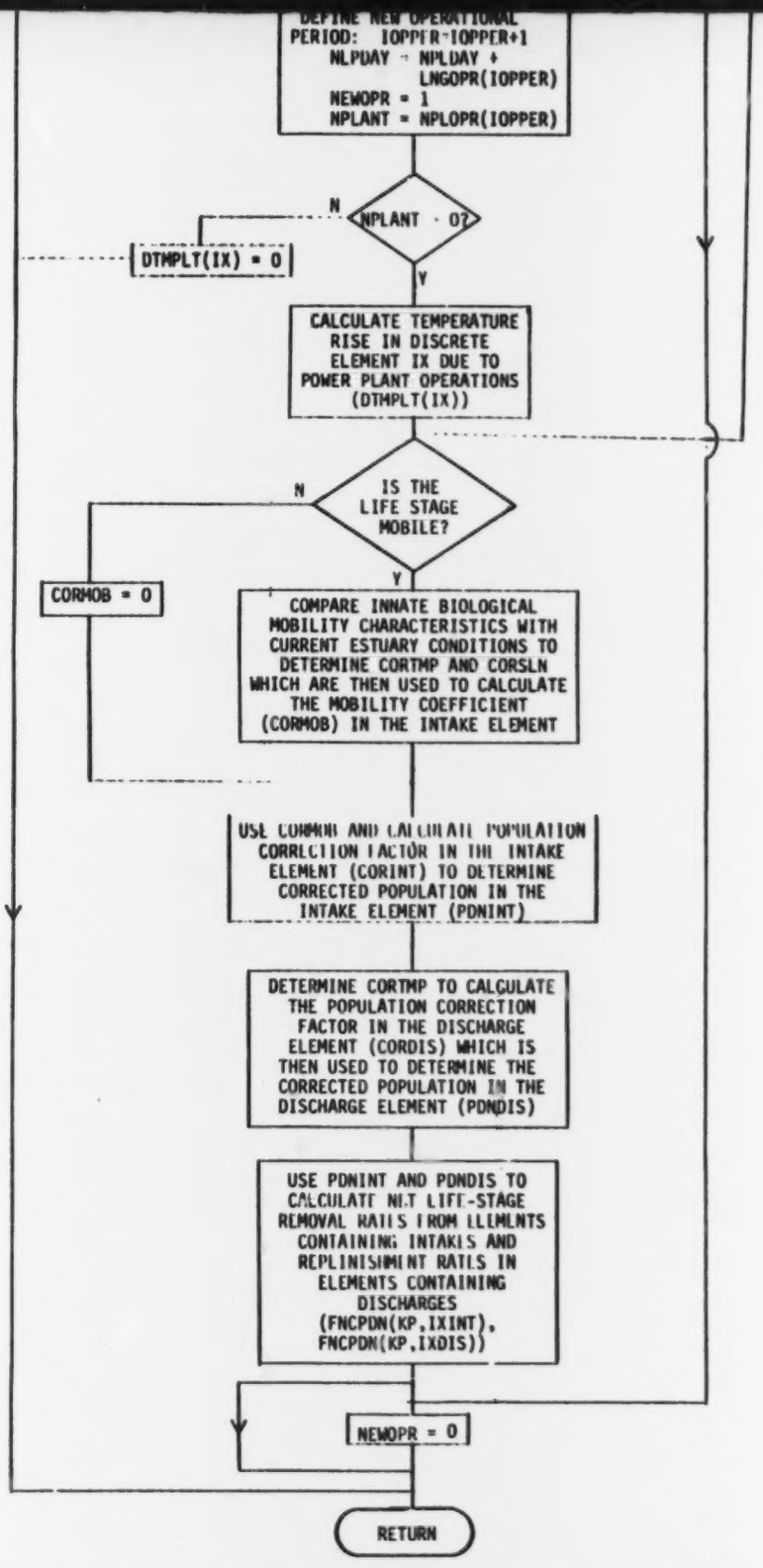
DEFINE NEW OPERATIONAL PERIOD: IOPPER=IOPPER+1
NLPDAY = NPLDAY + LNGOPR(IOPPER)
NEWOPR = 1
NPLANT = NPLOPR(IOPPER)
N
NPLANT .GT. 0?
Y
DTMPLT(IX) = 0
CALCULATE TEMPERATURE RISE IN DISCRETE ELEMENT IX DUE TO POWER PLANT OPERATIONS (DTMPLT(IX))
N
IS THE LIFE STAGE MOBILE?
Y
CORMOB = 0
COMPARE INNATE BIOLOGICAL MOBILITY CHARACTERISTICS WITH CURRENT ESTUARY CONDITIONS TO DETERMINE CORTMP AND CORSLN WHICH ARE THEN USED TO CALCULATE THE MOBILITY COEFFICIENT (CORMOB) IN THE INTAKE ELEMENT
USE CORMOB AND CALCULATE POPULATION CORRECTION FACTOR IN THE INTAKE ELEMENT (CORINT) TO DETERMINE CORRECTED POPULATION IN THE INTAKE ELEMENT (PDNINT)
DETERMINE CORTMP TO CALCULATE THE POPULATION CORRECTION FACTOR IN THE DISCHARGE ELEMENT (CORDIS) WHICH IS THEN USED TO DETERMINE THE CORRECTED POPULATION IN THE DISCHARGE ELEMENT (PDNDIS)
USE PDNINT AND PDNDIS TO CALCULATE NET LIFE-STAGE REMOVAL RATES FROM ELEMENTS CONTAINING INTAKES AND REPLENISHMENT RATES IN ELEMENTS CONTAINING DISCHARGES (FNCPDN(KP,IXINT), FNCPDN(KP,IXDIS))
NEWOPR = 0
RETURN

Fig. 6. Abridged flow chart of subroutine PLTCON.

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TRPORT (Fig. 7)

Subroutine TRPORT furnishes the STRIPE program with the conditions necessary to define the overall longitudinal transport phenomenon simulated in the program. In the initial phase (KRUN=0), the life-stage transport parameters are read and the dispersion coefficients at each enclosure surface, along with the life-stage shoaling and crowding coefficients, are determined. Estuary surface and bed conditions are then initialized and the life-stage transport conditions are written before return to the main program.

During the calculation phase (KRUN=1), the three transfer fluxes that describe life-stage transport - that due to convective defect transport, that due to migratory transport, and that due to tidal dispersion - are determined. At this time control flags MIGAGE (KP) and IKPMOB (KP) are important in calculating the migratory transport. If either of these variables for life stage KP is zero, then migratory transport is disabled for that life stage.

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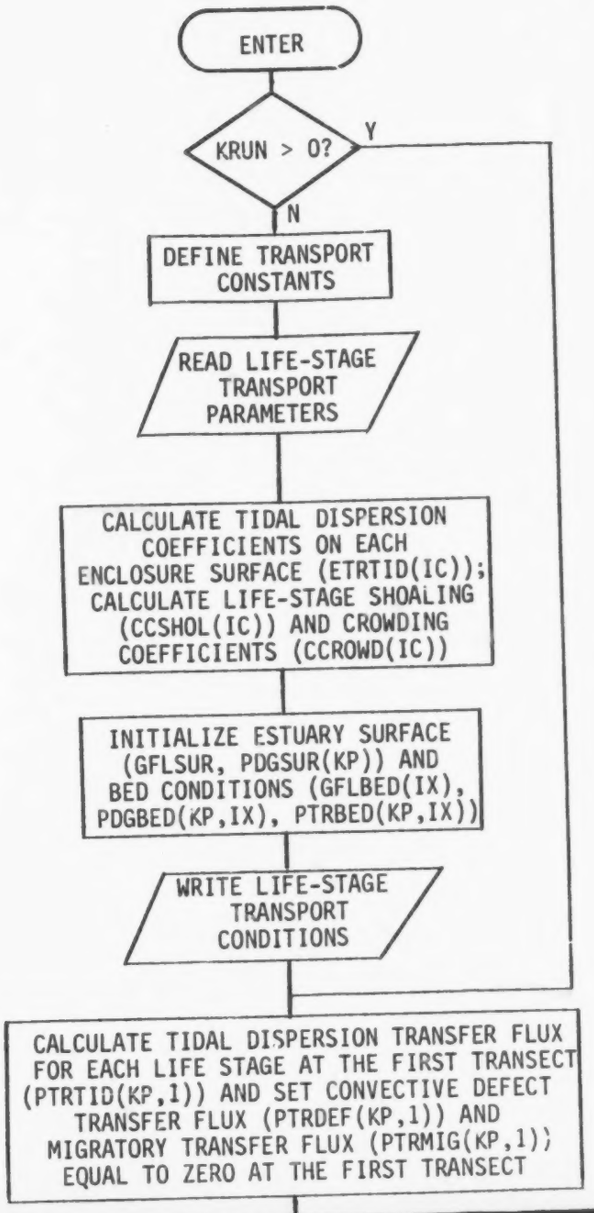
ENTER
KRUN > 0?
Y
N
DEFINE TRANSPORT CONSTANTS
READ LIFE-STAGE TRANSPORT PARAMETERS
CALCULATE TIDAL DISPERSION COEFFICIENTS ON EACH ENCLOSURE SURFACE (ETRTID(IC)); CALCULATE LIFE-STAGE SHOALING (CCSHOL(IC)) AND CROWDING COEFFICIENTS (CCROWD(IC))
INITIALIZE ESTUARY SURFACE (GFLSUR, PDGSUR(KP)) AND BED CONDITIONS (GFLBED(IX), PDGBED(KP,IX), PTRBED(KP,IX))
WRITE LIFE-STAGE TRANSPORT CONDITIONS
CALCULATE TIDAL DISPERSION TRANSFER FLUX FOR EACH LIFE STAGE AT THE FIRST TRANSECT (PTRTID(KP,1)) AND SET CONVECTIVE DEFECT TRANSFER FLUX (PTRDEF(KP,1)) AND MIGRATORY TRANSFER FLUX (PTRMIG(KP,1)) EQUAL TO ZERO AT THE FIRST TRANSECT

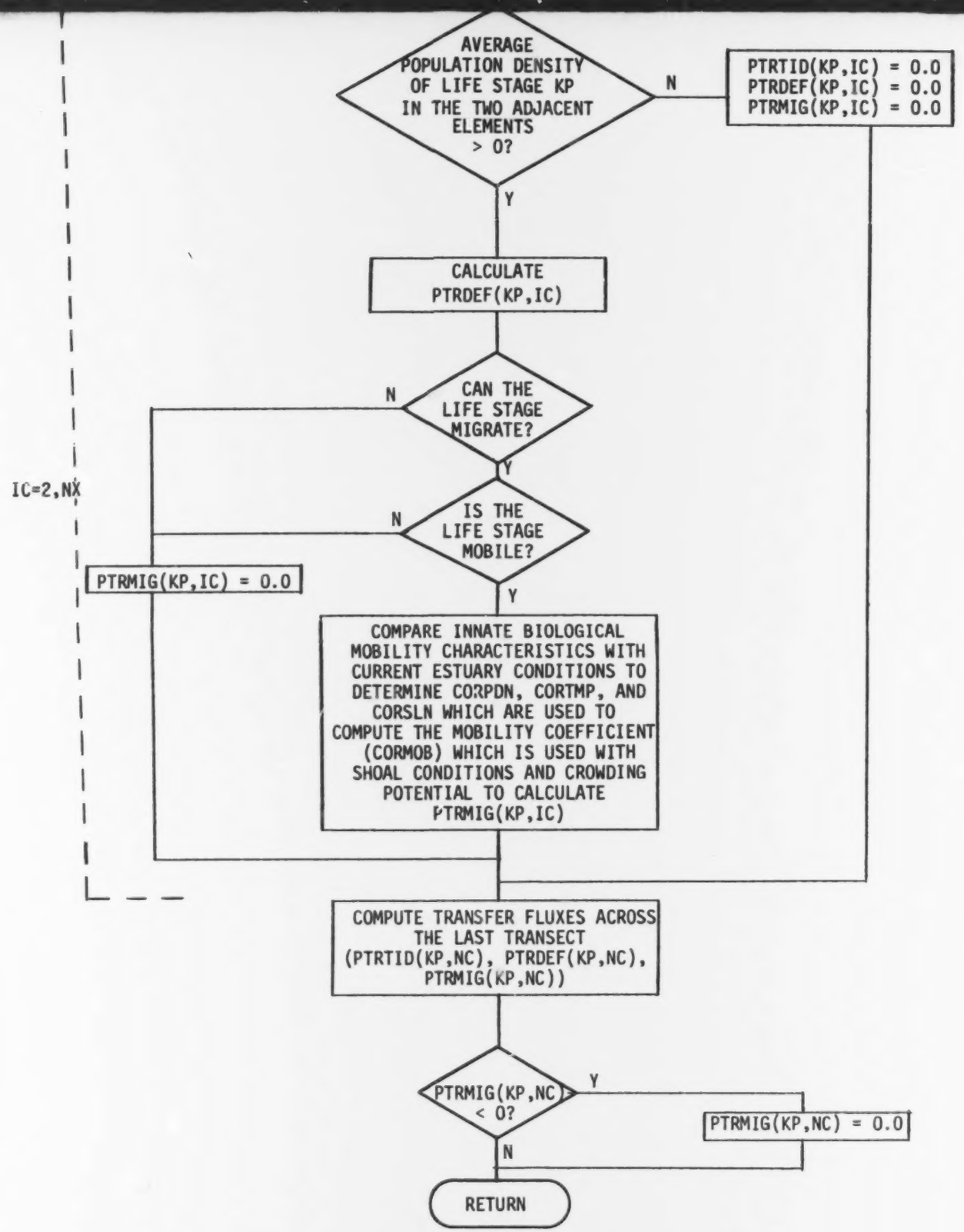
AVERAGE POPULATION DENSITY OF LIFE STAGE KP IN THE TWO ADJACENT ELEMENTS > 0?
N
PTRTID(KP,IC) = 0.0
PTRDEF(KP,IC) = 0.0
PTRMIG(KP,IC) = 0.0
Y
CALCULATE PTRDEF(KP,IC)
CAN THE LIFE STAGE MIGRATE?
N
Y
IC=2,NX
IS THE LIFE STAGE MOBILE?
N
PTRMIG(KP,IC) = 0.0
Y
COMPARE INNATE BIOLOGICAL MOBILITY CHARACTERISTICS WITH CURRENT ESTUARY CONDITIONS TO DETERMINE CORPDN, CORTMP, AND CORSLN WHICH ARE USED TO COMPUTE THE MOBILITY COEFFICIENT (CORMOB) WHICH IS USED WITH SHOAL CONDITIONS AND CROWDING POTENTIAL TO CALCULATE PTRMIG(KP,IC)
COMPUTE TRANSFER FLUXES ACROSS THE LAST TRANSECT (PTRTID(KP,NC), PTRDEF(KP,NC), PTRMIG(KP,NC))
PTRMIG(KP,NC) < 0?
Y
PTRMIG(KP,NC) = 0.0
N
RETURN

Fig. 7. Abridged flow chart of subroutine TRPORT.

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ENDCON (Fig. 8)

Subroutine ENDCON determines life-stage population densities at the ends of the estuary. In the initialization phase (KRUN=0), the life-stage population density from the ocean (PDNOCN(KP)) is set. During the calculation phase (KRUN=1), the life-stage population density at the upstream end of the estuary is set to that density in the first discrete element. If the freshwater flow rate through the last downstream transect is greater than zero, then the life-stage population density at the downstream end is extrapolated from the life-stage densities in the last two discrete elements. If the freshwater flow rate through the last transect is not greater than zero, the life-stage densities at the downstream end are set equal to that in the ocean.

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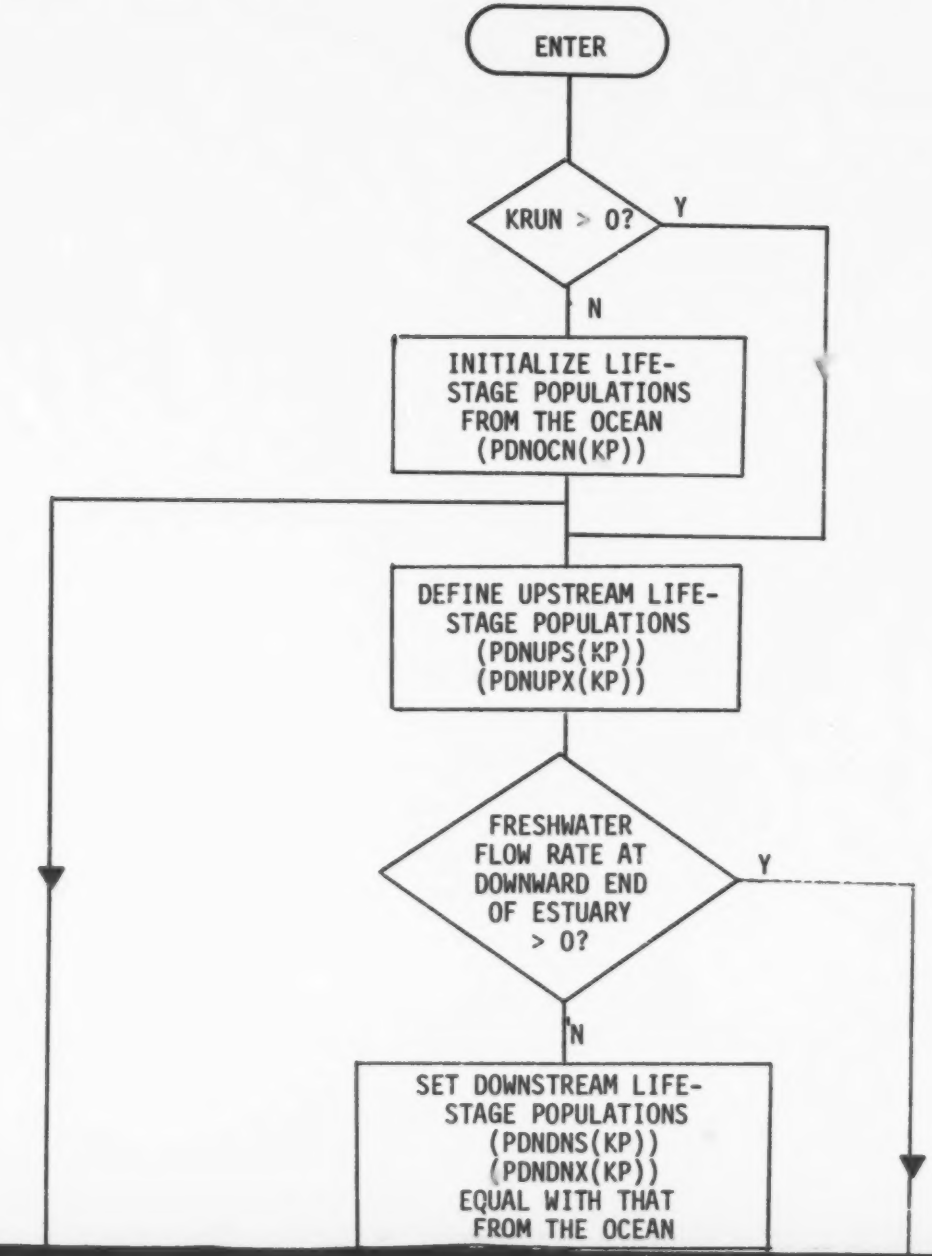
ENTER
KRUN > 0?
Y
N
INITIALIZE LIFE-STAGE POPULATIONS FROM THE OCEAN (PDNOCN(KP))
DEFINE UPSTREAM LIFE-STAGE POPULATIONS (PDNUPS(KP)) (PDNUPX(KP))
FRESHWATER FLOW RATE AT DOWNWARD END OF ESTUARY > 0?
Y
N
SET DOWNSTREAM LIFE-STAGE POPULATIONS (PDNDNS(KP)) (PDNDNX(KP)) EQUAL WITH THAT FROM THE OCEAN

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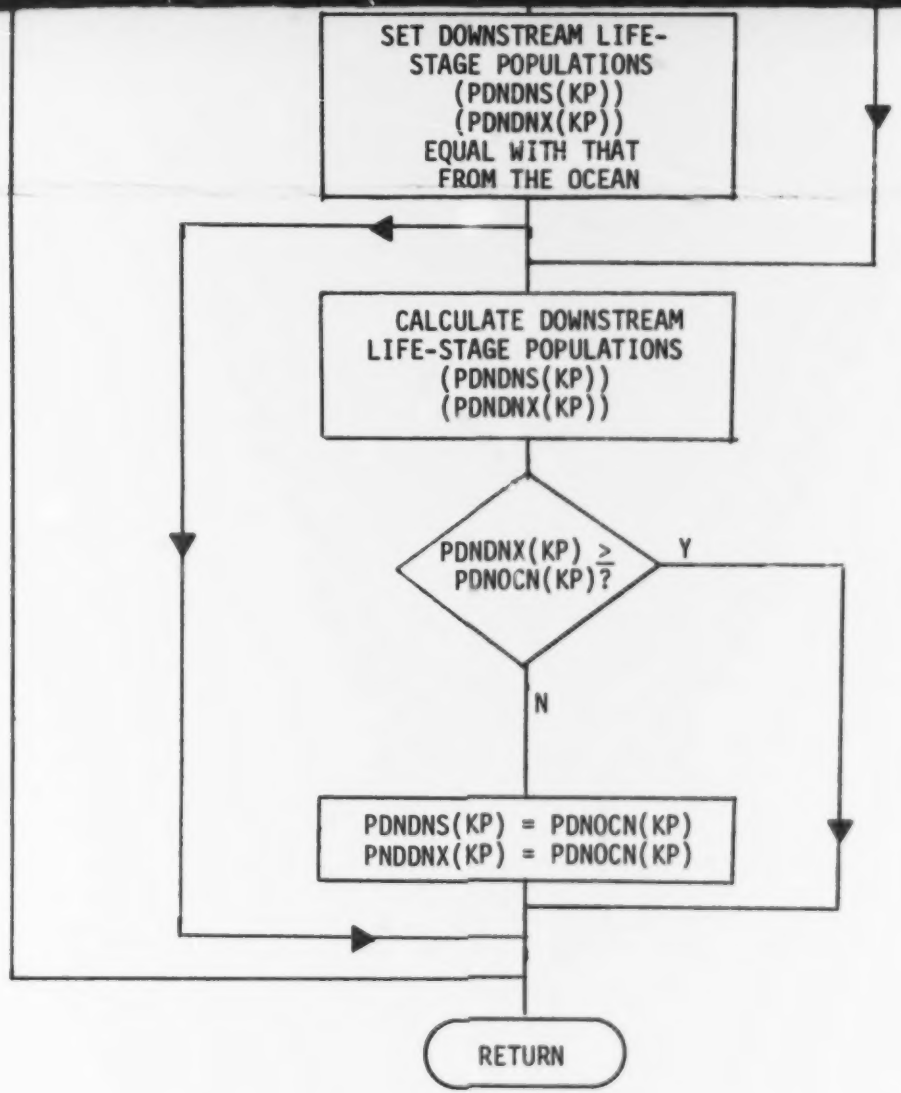

Fig. 8. Abridged flow chart of subroutine ENDCON.

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TRBCON (Fig. 9)

Subroutine TRBCON determines the contributions to the life-stage populations in the estuary from tributaries. In the initialization phase (KRUN=0), the tributary configuration is defined and the life-stage population densities in the tributaries are initialized. During the calculation phase (KRUN=1), the freshwater flow from each tributary is determined and the contribution to the total life-stage population in the appropriate discrete element from each tributary is calculated.

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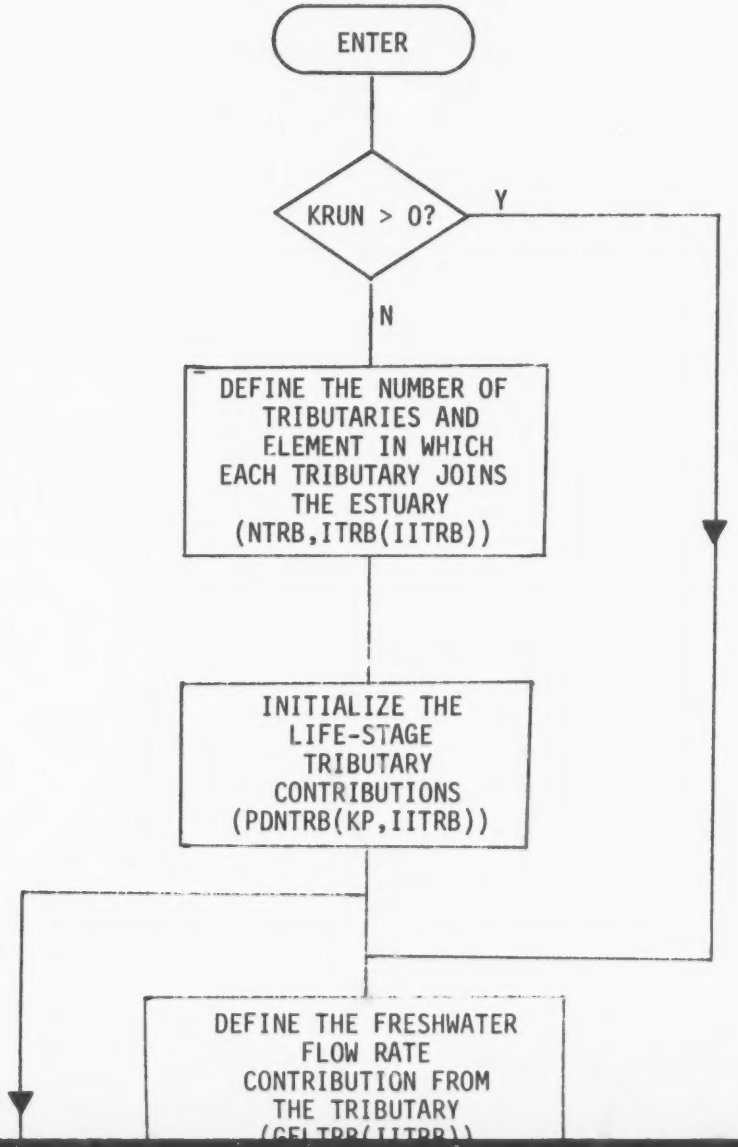
ENTER
KRUN > 0?
Y
N
DEFINE THE NUMBER OF TRIBUTARIES AND ELEMENT IN WHICH EACH TRIBUTARY JOINS THE ESTUARY (NTRB,ITRB(IITRB))
INITIALIZE THE LIFE-STAGE TRIBUTARY CONTRIBUTIONS (PDNTRB(KP,IITRB))
DEFINE THE FRESHWATER FLOW RATE CONTRIBUTION FROM THE TRIBUTARY

AVAILABLE

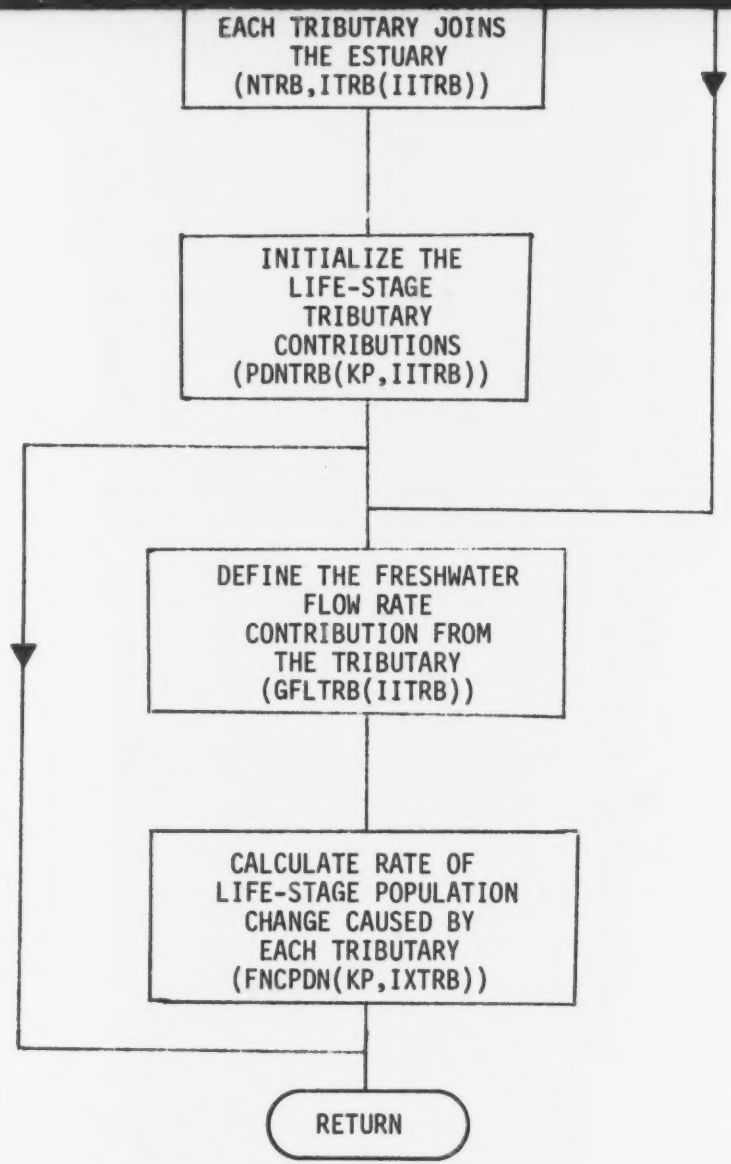
EACH TRIBUTARY JOINS THE ESTUARY (NTRB,ITRB(IITRB))
INITIALIZE THE LIFE-STAGE TRIBUTARY CONTRIBUTIONS (PDNTRB(KP,IITRB))
DEFINE THE FRESHWATER FLOW RATE CONTRIBUTION FROM THE TRIBUTARY (GFLTRB(IITRB))
CALCULATE RATE OF LIFE-STAGE POPULATION CHANGE CAUSED BY EACH TRIBUTARY (FNCPDN(KP,IXTRB))
RETURN

Fig. 9. Abridged flow chart of subroutine TRBCON.

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INITAL (Fig. 10)

Subroutine INITAL reads the starting time and the initial life-stage population densities as the initial conditions for the initial value problem. This routine is called only once at the beginning of the calculation phase (KRUN=1).

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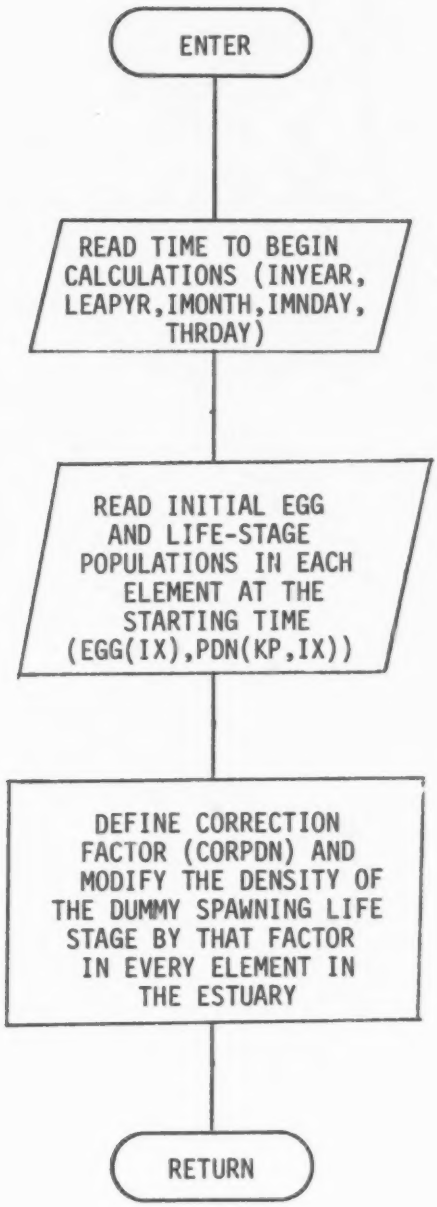
ENTER
READ TIME TO BEGIN CALCULATIONS (INYEAR, LEAPYR,IMONTH,IMNDAY, THRDAY)
READ INITIAL EGG AND LIFE-STAGE POPULATIONS IN EACH ELEMENT AT THE STARTING TIME (EGG(IX),PDN(KP,IX))
DEFINE CORRECTION FACTOR (CORPDN) AND MODIFY THE DENSITY OF THE DUMMY SPAWNING LIFE STAGE BY THAT FACTOR IN EVERY ELEMENT IN THE ESTUARY
RETURN

Fig. 10. Abridged flow chart of subroutine INITAL.

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OUTPUT (Fig. 11)

Subroutine OUTPUT furnishes the STRIPE program with written records of the population changes through the period of simulation. In the initialization phase (KRUN=0), OUTPUT writes the tidal-averaged geometric properties of the elements if IWRITE is greater than zero. In addition, if ISTORE is greater than zero, subroutine STORER is called.

In the calculation phase (KRUN=1), subroutine ENDCON is called for conditions at the estuary ends. Then, if IWRITE is greater than zero, the tidal-averaged estuary conditions and population results are written. Again, if ISTORE is greater than zero, subroutine STORER is called to retain the population results for later output. If KRUN is equal to 2 (the calculation is complete) and ISTORE is greater than zero, subroutine STORER is called for special output of the stored results. Finally, if IPUNCH is greater than zero, results are saved so that the simulation can be continued.

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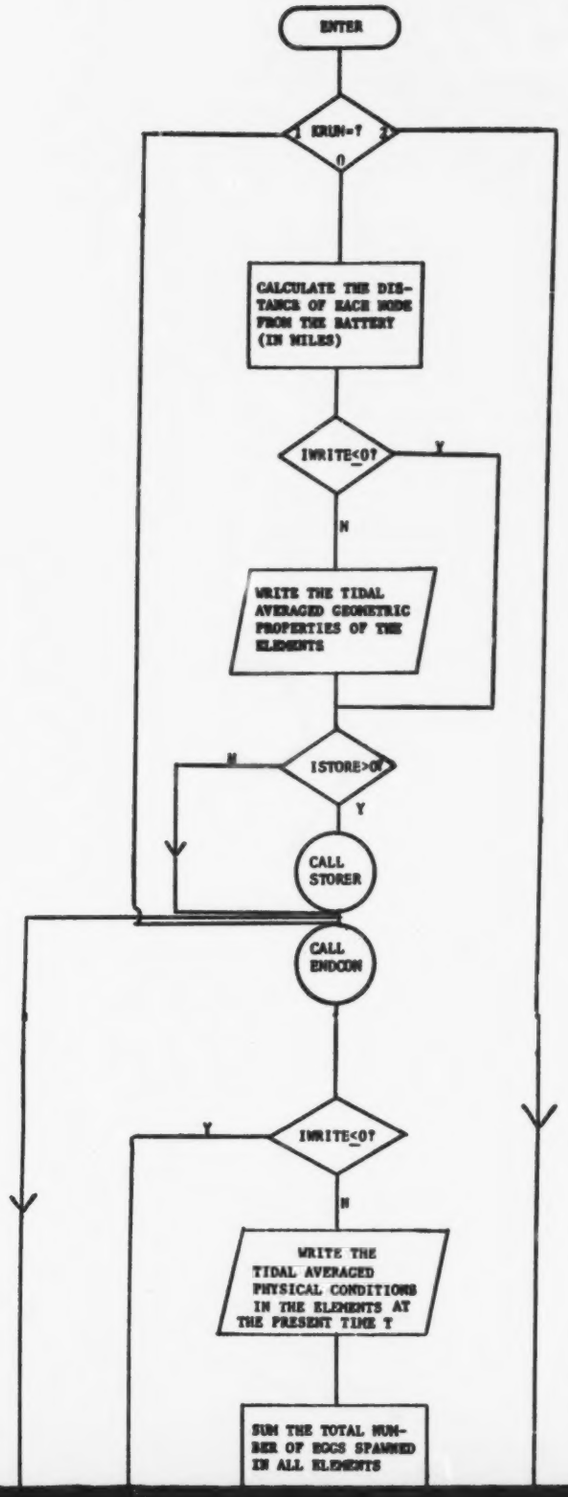

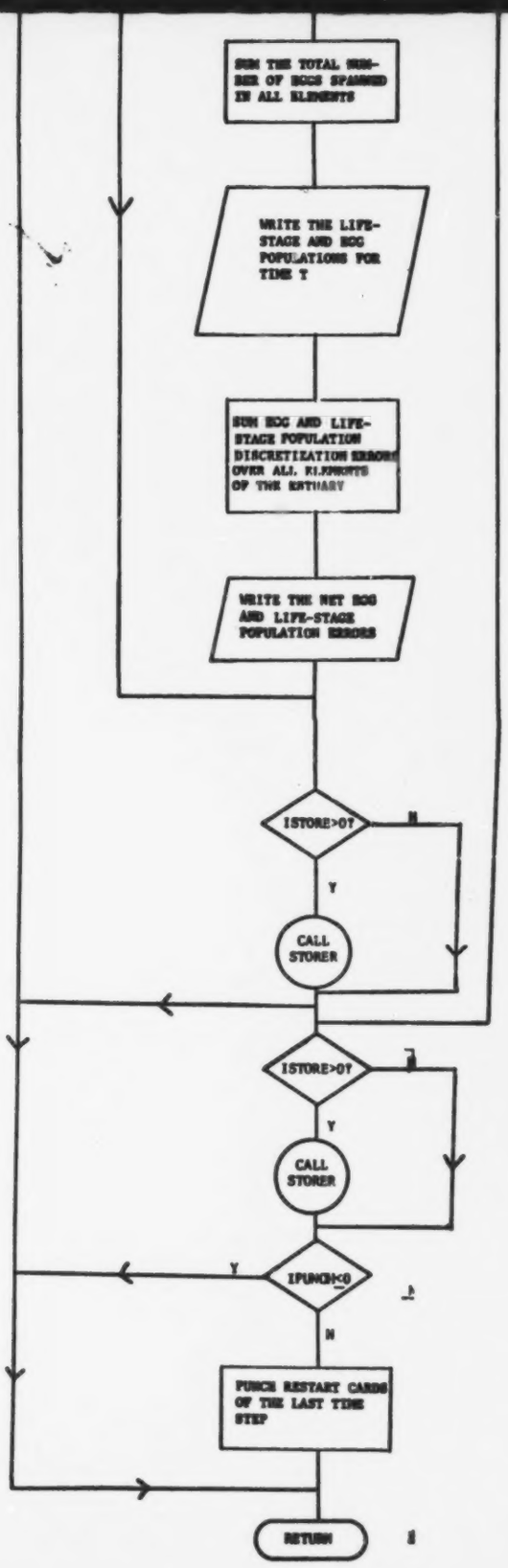

Fig. 11. Abridged flow chart of subroutine OUTPUT.

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SOLVER

SOLVER solves the initial value ordinary differential equations that describe the temporal change in population density in the estuary. The mathematical method used is a fourth-order Runge-Kutta algorithm with Gill coefficients. This technique gives fourth-order accuracy by using the minimum number of storage registers. If the solution step size (DTHR) chosen by the user preserves the explicit condition for solution stability over the total range of the estuary, a stable solution is guaranteed. If the user desires to use his own numerical routine or technique for solution, he can easily add his changes, but he must ensure that all parameters are passed in the same manner as with SOLVER (i.e., by the subroutine argument list and by the same labeled common blocks).

SOLVER is also called once in the initialization phase (KRUN=0), like most of the other subroutines, to initialize all constants in the mathematical formulation. In the calculation phase (KRUN=1), SOLVER calls SOLFNC for the right-hand side of the differential equations describing population density and finds their solutions. It is noted that there is a lower bound on population density (PDNMIN). Any population densities less than PDNMIN are set to zero. PDNMIN should be set small enough so that any smaller numbers are insignificant. PDNMIN ensures that no negative populations can occur. The flow chart for SOLVER was omitted since most users of this routine are not interested in its mode of operation and would not care to change it.

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PROGRAM INPUT, OUTPUT, AND IMPLEMENTATION

Data Card Input

The main program and five subroutines, BIOCON, E3TCON, INITAL, PLTCON, and TRPORT, read cards in the initialization phase (KRUN=0) of STRIPE. In addition, subroutine INITAL and the main program read cards in the computational phase (KRUN=1) before the life-stage populations are computed over time. Sample case input cards are shown in Appendix C, Table C.1, in the order in which they are read, separated according to which subroutine reads them. Note that flags IKPSPW(KP), IKPGRW(KP), IKPMOR(KP), and IKPMOB(KP) help determine which biological parameters are read in BIOCON.

Output

Output from a typical run of STRIPE is controlled by several variables and flags that are defined in the main program. First of all are the flags IWRITE, ISTORE, IPUNCH, IPDIST, IPNDIS, IPDDIS, IPNTIM, IPDTIM, and IPNTOT. IWTAPE, which is also read in the main program, is not used in the current version. It will be used to determine whether to record the time-dependent population records on magnetic tape in order to save a permanent file of the populations. Below is a brief description of the purpose of each flag:

FLAG	VALUE	RESULT
IWRITE	if > 0	Means full written output in subroutine OUTPUT.
	if 0	Means no written output from OUTPUT.
ISTORE	if > 0	Means OUTPUT calls STORER to produce additional output.
	if 0	Means STORER is not used.
IPUNCH	if > 0	Means restart records from the last calculations are saved.
	if 0	Means no restart records are saved.

IWTAPE	if	0	Means subroutine OUTAPE will write population records on magnetic tape every time that subroutine OUTPUT is called in the calculation phase of STRIPE.
	if	0	Means no records on magnetic tape.

The flags IPDIST, IPNDIS, IPDDIS, IPNTIM, IPDTIM, and IPNTOT are used to control the types of plots from a computer run. They are described in Appendix B.

In addition, the main program also reads three important output controlling variables at the onset of the computational phase of STRIPE - NT(NTOTHR), NTW(NWRITE), and DT(DTHR). NT is the number of time steps (of step size DT) used by the integration technique. NTW determines at what times subroutine OUTPUT is called [every (NTW x DT) hours]. See Appendix C, Table C.2, for a written account from subroutine BIOCON of the AGE GROUP BIOLOGICAL CONDITIONS for the sample case. See Table C.3 for the AGE GROUP TRANSPORT CONDITIONS from subroutine TRPORT. See Table C.4 for an account of the AGE GROUP PLANT AVOIDANCE AND SURVIVAL CHARACTERISTICS and Table C.5 for PLANT OPERATIONAL CONDITIONS DURING SPECIFIED PERIODS from subroutine PLTCON. Table C.6 gives the TIDAL-AVERAGED GEOMETRIC PROPERTIES OF THE ELEMENTS written in the initialization phase of subroutine OUTPUT if IWRITE > 0. Table C.7 is the TIDAL-AVERAGED PHYSICAL CONDITIONS IN THE ELEMENTS, and Table C.8 is the TOTAL NUMBER OF SPAWNED EGGS AND POPULATION DENSITY OF AGE GROUPS IN THE ELEMENTS. With IWRITE > 0, records like Table C.7 and Table C.8 will be printed every time subroutine OUTPUT is called in the computational phase.

Implementation

Compilation of all the FORTRAN IV subroutines of the STRIPE program requires 31 CPU seconds and 270K of core storage on a FORTRAN-H-level compiler (as loaded on an IBM 360/91 computer). In addition, execution of the sample program in this report used 3.5 min of computational time and 176K of memory to simulate 24 weeks in the estuary. The amount of core required for execution, on a particular computer, however, can be reduced if the machine used supports a LOGICAL*1 declaration that may be used with the routines for plotting (see the Note after the discussion of subroutine TPLOTS). The Job Control Language used to run a sample case of STRIPE at the Oak Ridge National Laboratory Computing Center is listed below:

```
//DASFES07 JOB (15530),'X-10 2001 RD SHARP'
//*CLASS CPU91=5M,IO=20,LINES=18,REGION=270
// EXEC FORTHCLG,PARM.FORT='XREF',PARM.GO='EU=-1',
// REGION.GO=270K
//FORT.SYSIN DD *
 ------------------------ FORTRAN DECK GOES HERE
/*
//GO.FT07F001 DD SYSOUT=B
//GO.FT05F001 DD *
   ---------------------- DATA DECK GOES HERE
/*
//
```

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CONCLUSIONS

The development of the daily transient (tidal-averaged), longitudinally one-dimensional (cross-section-averaged) computer simulation model for the striped bass young-of-the-year in the Hudson River illustrated that the mathematical foundations of the transport theories associated with the physical phenomena can be readily expanded to incorporate the important physiological and behavioral characteristics of the life stages of a biological population.

The longitudinal convective transport of the striped bass life-stage populations was formulated based on the net freshwater flow in the estuary (consistent with the tidal-averaged assumption of the general model). Simulation of the observed 1973 longitudinal distributions of the life-stage populations indicated that the downstream transport of the early life stages (eggs, yolk-sac larvae, and post-yolk-sac larvae) was significantly slower than the net freshwater flow in the Hudson River. It was evident that even these early life stages do not behave as uniformly distributed passive organisms. Rather, they must exhibit significant vertical and/or lateral variations in their distributions with relatively higher concentrations occurring near the bottom and/or near the shores, where the downstream flow conditions are relatively lower than in the main channel of the river.

This result is important in assessing the impact of power plant operations on the young-of-the-year populations. Since these early life stages are transported downstream slower than the net freshwater flow, as they pass a given power plant they are susceptible to entrainment at the intakes for longer durations than one would expect for passive organisms moving

with the net freshwater flow. Furthermore, nonuniform vertical and/or lateral distributions of these early life stages can influence the rate of entrainment, depending on the locations, structural details, and the flow rates at the intakes, as well as the bathymetry and the flow conditions in the river.

In the present model these three-dimensional effects were approximated by considering convective defect transport fluxes and "f" factors, which represent the ratios of the intake population densities to the cross-section-averaged population densities in the river (consistent with the one-dimensional assumption of the general computer simulation model). The convective defect transport fluxes were determined based on simulations of the 1973 longitudinal distributions, and the "f" factors were estimated based on the limited data about the life-stage population densities in the intake flows. Although the present tidal-averaged, one-dimensional model attempts to incorporate these distributional effects, it must be realized that the vertical and lateral density variations of the early life stages and the hydrodynamic conditions in the estuary can never be completely described within the general scope of a one-dimensional (cross-section-averaged) formulation. From a theoretical point of view at least, such a complete description would require a three-dimensional transport model for the striped bass young-of-the-year in the Hudson River.

Certain of the physiological and behavioral characteristics of the striped bass young-of-the-year life stages were considered in detail in the present model. The transfer of populations from earlier to later life stages was formulated in terms of apparent survival probabilities and growth and mortality rates. The possible existence of various mechanisms

for biological compensation was included by considering multiplicative factors which can separately vary the apparent survival probabilities and growth and mortality rates as a function of the population density, temperature, and salinity were not actually implemented. Further laboratory and field studies are required.

The migration of the juvenile life stages to the shoal areas along the estuary was formulated according to a novel, gradient-type model which represents the net balance between the effects of shoaling preference and overcrowding. The simulation of the longitudinal distributions of weekly averaged juvenile standing crops agreed very well with the 1973 data. Thus, the migration of the striped bass juvenile life stages can be modeled wihout restrictive formulations based on the observed longitudinal distributions.

The rates of reduction by entrainment and impingement at the power plants were formulated by considering (a) the ratios of the population densities of the entrainable life stages (eggs, yolk-sac larvae, post-yolk-sac larvae, and early juveniles) entering the intakes to the average densities in the river ("f" factors), (b) avoidance factors (for juveniles) based on temperature and salinity-dependent mobility characteristics, (c) geometric factors for the intakes and the discharges, and (d) the temperature-dependent survival probabilities of the entrainable life stages upon passage through cooling water systems of the power plants. Parameter values or a range of values were selected, based on available data at the various power plants; the data, in some instances, were rather limited.

The comparisons of the preliminary numerical solutions from the model with the 1973 data clearly indicated that the model is acceptable both from

qualitative and quantitative considerations for simulating the longitudinal and temporal distributions of the life-stage population densities in the estuary. Several of the discrepancies between the simulations and the observed data suggest inadequacies and inconsistencies in the 1973 data.

In conclusion, the present computer simulation model represents a general, daily transient (tidal-averaged), longitudinally one-dimensional (cross-section-averaged) transport model for the striped bass young-of-the-year life stages in the Hudson River. It can be readily employed as a tool for predicting the yearly reduction in the striped bass young-of-the-year population due to the entrainment and impingment damage at the intakes of the power plants on the Hudson River.

REFERENCES

1. Eraslan, A. H., W. Van Winkle, R. D. Sharp, S. W. Christensen, C. P. Goodyear, R. M. Rush, and W. Fulkerson. 1976. A computer simulation model for the striped bass young-of-the-year population in the Hudson River. Oak Ridge National Laboratory, Oak Ridge, Tennessee. ORNL/NUREG-8, Special.

2. U. S. Nuclear Regulatory Commission (NRC). 1975. Final environmental statement related to operation of Indian Point Nuclear Generating Plant, Unit No. 3. Consolidated Edison Company of New York, Inc., Docket No. 50-286. Two volumes.

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APPENDIX A. PROGRAM LISTING AND GLOSSARIES

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Microfiche of Program Listing for

STRIPE

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DESCRIPTION OF THE GLOSSARIES

Both glossaries in this user's manual (page 77 through page 117) give definitions of variables sorted in alphabetical order. The first glossary beginning on page 77 also gives the name of the labeled common block by which the variable is passed. Furthermore, other useful information about each variable follows the definition of the variable in both glossaries. This extra information begins with four letters and is followed by one or more numbers. Each set of four letters refers to a particular subroutine and the numbers following are positional indicators for the subroutine. The actual statement for each reference can be found by looking at columns 73 through 80 of the FORTRAN program listings.

Certain other information may also be obtained from these sequence numbers. If the number is enclosed in a box, this means that the variable is read at that statement. If it is underlined, the variable appears on the left side of an equals sign. An asterisk appearing by a variable name indicates that the variable is really a subroutine, and a description of the function of the subroutine and the locations where the subroutine is used follow.

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GLOSSARY OF VARIABLES PASSED BY COMMON

VARIABLE		COMMON
ACC(IC)	Cross-sectional area (ft^2) of transect IC ESTC [220], 320 SOLF 350, 360 TRPO 1300, 1920	GEOCRS
ACR(IX)	Average cross-sectional area (ft^2) in discrete element IX ESTC 330 SOLF 340 PLTC 1670, 1770, 1910, 1930 TRBC 230 OUTP 410, 1240 STOR 400	GEOELM
AMONTH(IMONTH)	Name of month IMONTH MAIN [480] OUTP 560 DPLO 760, 1100, 1400	CALDAT
APLDIS(IDNPLT)	Cross-sectional area (ft^2) of discharge for plant IDNPLT PLTC [230], 1140, 1190	CONPLT
APLINT(IDNPLT)	Cross-sectional area (ft^2) of intake for plant IDNPLT PLTC [280], 1020, 1070, 1960	CONPLT
BIOCON*	Subroutine that reads (and writes) the biological parameters and furnishes SOLFNC with the updated biological factors that affect the life-stage populations MAIN 520 SOLF 280	
BSC(IC)	Surface width (ft) of transect (cross section) IC ESTC [220], 250, 360, 400	GEOCRS

[ ] means card(s) read to define variable.

— means possible assignment (variable appears at the left of an equal '=' sign).

* means subroutine.

VARIABLE		COMMON
BSR(IX)	Average surface width (ft) in discrete element IX ESTC 370 SOLF 370 OUTP 450	GEOELM
CCCTID	Coefficient of tidal dispersion expression (specified) TRPO 240, 270	CONTID
CFRBOT	Bottom friction coefficient for turbulent flow in estuaries (specified) TRPO 260, 270, 280	CONTID
CINAVD(KP)	Intake avoidance parameter for life stage KP PLTC 330, 590, 2270	PLTSRV
CINPDN(KP)	Intake population density factor (i.e., ratio of the population density in the immediate vicinity of an intake to the mean population density in the discrete element of the intake) for life stage KP PLTC 330, 550, 2270	PLTSRV
CNDSRV(KP)	Optimum plant survival probability for life stage KP upon passage through a power plant cooling system PLTC 330, 620, 2380	PLTSRV
COPSRV(KP)	Optimum apparent survival probability of life stage KP BIOC 440, 1240, 4370, 4380	CONSRV
CTRTID	Combined coefficient of tidal dispersion expression TRPO 270, 370, 470 PLTC 1660, 1760	CONTID
DHB(IX)	Average maximum channel depth (ft) in discrete element IX ESTC 350 PLTC 1660, 1680, 1760, 1780 OUTP 400	GEOELM

VARIABLE		COMMON
DHC(IC)	Maximum channel depth (ft) of transect IC ESTC 220, 250, 340, 400 TRPO 370, 470	GEOCRS
DPLOTS*	Subroutine that plots life-stage populations against distance from the Battery at a given time t STOR 510, 1120, 1710	
DTMPCD (IOPPER, IPLANT)	Condenser temperature rise (°F) during period IOPPER for plant IPLANT PLTC 450, 1240, 1600, 1970	PLTOPR
DTMPLT(IX)	Excess temperature (°F) in discrete element IX due to power plant operation ESTC 880, 920, 950 PLTC 1300, 1520, 1610, 1710, 1810	PLTOPR
DTVMOB(KP)	Approximate sustained duration (hr) at maximum swimming speed for life stage KP BIOC 710, 2420 TRPO 1670, 1690, 2290, 2310	CONMOB
DVRPDN(KP)	Percentage of the mean value which is higher at the bottom and lower at the surface from the mean for life stage KP TRPO 300, 820, 1320, 1940	CONMIG
DX(IX)	Longitudinal length (ft) of discrete element IX ESTC 300, 630, 640, 1200, 1210 SOLF 330 ENDC 140 TRPO 400, 410, 490, 1040, 1140, 1150, 1780 PLTC 1900, 1920 TRBC 220 OUTP 390, 1240 STOR 400	GEOELM
EGG(IX)	Cumulative number of eggs spawned in discrete element IX SOLV 480 OUTP 910, 930, 1470 INIT 100	EGGSOL

VARIABLE		COMMON
ENDCON*	Subroutine that determines the life-stage population conditions at the ends of the estuary MAIN 550 SOLF 270 OUTP 530	
ERREGG(IX)	Discretization error of the solution for number of eggs spawned in discrete element IX SOLV 320, 470, 490	EGGSOL
ERRPDN(KP,IX)	Discretization error of the solution for population density of life stage KP in discrete element IX SOLV 300, 420, 440, 443 OUTP 1250	PDNSOL
ESTCON*	Subroutine that reads the parameters of the discrete elements and furnishes updated conditions for flow rates, temperatures, and salinities in the estuary during the calculational scheme MAIN 510, 810, 1070	
FNCEGG(IX)	Time rate of deposition of egg population density (number/hr) in discrete element IX SOLV 460 SOLF 230, 810	EGGSOL
FNCPDN(KP,IX)	Net time rate of change of life stage KP's population (number/(ft^3 hr)) in discrete element IX SOLV 410 SOLF 210, 790, 860	PDNSOL
GEODIS(IDNPLT)	Discharge geometric factor for plant IDNPLT PLTC 290, 1160, 2370	CONPLT
GEOINT(IDNPLT)	Intake geometric factor for plant IDNPLT PLTC 290, 1040, 2270	CONPLT
GFC(IC)	Freshwater flow rate (ft^3/hr) across transect IC ESTC 870, 940, 1230 SOLF 390, 400 ENDC 210 TRPO 1300, 1920	CONCRS

VARIABLE		COMMON
GFLBED(IX)	Flow rate per unit area ($ft^3/(hr\ ft^2)$) on the estuary bed contour of discrete element IX SOLF 770 TRPO 560	CONBED
GFLDIS (IOPPER, IPLANT)	Discharge flow rate (ft^3/hr) from plant IPLANT during period IOPPER PLTC 450, 1180, 1590, 2420	PLTOPR
GFLINT (IOPPER, IPLANT)	Net flow rate (ft^3/hr) of the intake of plant IPLANT during period IOPPER PLTC 440, 1060, 2400	PLTOPR
GFLSUR	Flow rate per unit area on the estuary surface ($ft^3/(hr\ ft^2)$) (from rainfall, etc.) SOLF 760 TRPO 510	CONSUR
GFLTRB(IITRB)	Net nontidal flow rate (ft^3/hr) into the discrete element from tributary IITRB TRBC 190, 260	CONTRB
GFR(IX)	Average freshwater flow rate (ft^3/hr) in discrete element IX ESTC 910, 1230 PLTC 1590, 1670, 1770 TRBC 190 OUTP 710	CONELM
GFRFAC(IXC)	Flow rate factor in element IXC relative to Green Island ESTC 440, 910, 940	CONFAC
GFRPER(IPER)	Averaged freshwater flow rate (ft^3/hr) during period IPER (as measured at Green Island--read as c.f.s. but changed in ESTCON to ft^3/hr) ESTC 510, 530, 850	CONPER
GMC(IC)	Bed contour length (ft) in transect IC ESTC 220, 380	GEOCRS
GMR(IX)	Average length (ft) of the estuary bed contour in discrete element IX ESTC 390 SOLF 380	GEOELM

HCPSUR	Combined coefficient for calculating excess temperature due to power plant operations (specified) PLTC 230, 1690, 1790	CONTID
IDAYOY	Number of days after start of spawning period MAIN 720, 920 ESTC 750, 790, 1280 BIOC 2910 PLTC 1400, 1440, 2460 OUTP 550 DPLO 750, 1060, 1360	DATIME
IKPGRW(KP)	Growth flag for life stage KP BIOC 490, 520, 610, 1570, 3620	CONGRW
IKPMOB(KP)	Mobility flag for life stage KP BIOC 670, 700, 2340 TRPO 1340, 1960 PLTC 1990	CONMOB
IKPMOR(KP)	Mortality flag for life stage KP BIOC 580, 1940, 3930, 4230	CONMOR
IKPSPW(KP)	Spawning flag for life stage KP BIOC 340, 370, 830, 2930	COPSPW
IMNDAY	Day number of the month MAIN 710, 910, 940, 950 OUTP 550, 1440 INIT 70 DPLO 780, 1090, 1390	DATIME
IMONTH	Month number of the year MAIN 470, 480, 670, 940, 950, 960, 970, 980 OUTP 560, 1440 INIT 70 DPLO 790, 1100, 1400	DATIME
INITAL*	Subroutine that reads the starting time and initial egg and life-stage densities at the starting time MAIN 640	
INYEAR	Number of the year (e.g., 1973) MAIN 990 OUTP 560, 1440 INIT 70	DATIME

VARIABLE		COMMON
IPDDIS†	Flag that determines if select five-element-averaged life-stage PDN plots are made for each week MAIN 590 STOR 470, 620, 1670 DPLO 520, 1110	CNPLOT
IPDIST†	Flag that determines whether select PDN plots are made each time Subroutine OUTPUT is called in the calculation phase MAIN 590 STOR 470, 520, 1110, 1150	CNPLOT
IPDTIM	Flag that determines if select segment five-element-averaged PDN plots of the whole time period by weeks are made MAIN 590 STOR 680, 1960, 1990, 2010, 2040 TPLO 470, 770	CNPLOT
IPLOPR (IOPPER, IPLANT)	Reference number assigned to operating plant IPLANT during period IOPPER PLTC 440, 960, 1570, 1870	PLTOPR
IPNDIS†	Flag that determines if select five-element-averaged total number life-stage plots are made for each week MAIN 590 STOR 470, 620, 1670 DPLO 510	CNPLOT
IPNTIM	Flag that determines if plots of the total populations for all life stages averaged over five elements (segments) are made for the whole simulation period (by weeks) MAIN 600 STOR 680, 1960, 2000, 2020, 2050 TPLO 470, 530	CNPLOT

† means populations plotted against miles from Battery.

VARIABLE		COMMON
IPNTOT	Flag that determines if the total for each life stage is plotted for the whole simulation period (by weeks) MAIN 600 STOR 1960, 1980 TPLO 970	CNPLOT
IPUNCH	Flag that determines if restart data cards are punched MAIN 590 OUTP 1430	PUTOUT
ISTORE	Flag that determines if STORER is called to internally store results for later output MAIN 590 OUTP 500, 1390, 1420	PUTOUT
ITRB(IITRB)	Discrete element number in which tributary IITRB joins the estuary TRBC 130, 210	CONTRB
IWRITE	Flag that determines if full written output is given MAIN 590 OUTP 270, 540	PUTOUT
IWTAPE	Flag that can be used to store results on magnetic tape MAIN 590	PUTOUT
IXPDIS(IDNPLT)	Number of the discrete element in which discharge from plant IDNPLT is located PLTC 280, 1120, 1580	CONPLT
IXPINT(IDNPLT)	Number of the discrete element in which intake to plant IDNPLT is located PLTC 270, 1000, 1880	CONPLT
JULDAY	Julian calendar day MAIN 660, 690, 710, 720, 930 1000, 1010 OUTP 550 DPLO 750, 1060, 1360	DATIME

VARIABLE		COMMON
KRUN	Flag that determines operation mode of the code: KRUN = 0 means initialization; KRUN = 1 means computations; KRUN = 2 means special output MAIN 460, 630, 1130 ESTC 140 SOLF 180 BIOC 260 ENDC 100 TRPO 210 PLTC 210 TRBC 110 OUTP 150 STOR 220 DPLO 260	CONTRL
LEAPYR	Variable that indicates if present year is a leap year MAIN 650, 1000, 1030, 1040 OUTP 1440 INIT 70	CALDAT
LNGOPR(IOPPER)	Length (days) of plant operation during time period IOPPER PLTC 390, 810, 890, 1390, 1460	PLTOPR
LNGPER(IPER)	Length (days) of period IPER ESTC 510, 740, 810	CONPER
MAXDAY(KP)	Last day of survival period for life stage KP BIOC 310, 840, 1210, 1580 1950, 2350 TRPO 790, 910	GROUPS
MIGAGE(KP)	Migration flag for life stage KP TRPO 300, 900, 1330, 1950	CONMIG
MINDAY(KP)	First day of survival period for life stage KP BIOC 310, 840, 1210, 1580 1950, 2350 TRPO 790, 910	GROUPS

VARIABLE		COMMON
NC	Total number of estuary cross sections (transects) ESTC 170, 190, 200, 210, 680, 940, 950, 1060, 1160 ENDC 210 TRPO 470, 480, 490, 500, 1760, 1770, 1840, 1850, 1860, 1890, 1900,1920, 1940, 2290, 2310, 2350, 2370 OUTP 200, 220 DPLO 560, 610	CONTRL
NEWOPR	Flag that denotes a new plant operational period ESTC 830 PLTC 1330, 1480, 2510	PLTOPR
NMNDAY(IMONTH)	The number of days in month IMONTH MAIN 480, 650, 690, 940, 950 1020, 1040	CALDAT
NOPPER	The number of time periods for different plant-operational conditions PLTC 360, 380, 790, 1380	PLTOPR
NP	Total number of life stages in the model SOLV 290, 400, 530 SOLF 200, 410, 860 BIOC 280, 300, 340, 360, 430, 490, 510, 580, 600, 670, 690, 820, 1200, 1560, 1930, 2330, 2780, 2920, 3290 ENDC 110, 180 TRPO 290, 520, 570, 780, 890, 1030, 1170, 1790 TRBC 140, 240 OUTP 960, 1000, 1010, 1150, 1200, 1360, 1470 INIT 100	CONTRL
NPLANT	The present number of operating plants SOLF 840 PLTC 420, 430, 940, 950, 1490 1500, 1560, 1860	PLTOPR
NPLOPR(IOPPER)	The number of operating plants for time period IOPPER PLTC 390, 410, 420, 930, 940, 1490	PLTOPR

VARIABLE		COMMON
NPLTOT	Total number of possible operational plants in the sampled region PLTC 240, 260	CONPLT
NSPDAY	Number of spawning days MAIN 720 BIOC 280 PLTC 760, 770	GROUPS
NT	Total number of time steps used in the Runge-Kutta scheme MAIN 760, 830	CONTRL
NTRB	Total number of tributaries in the estuary SOLF 830 TRBC 120, 200	CONTRB
NTW	The number of time steps between written output MAIN 770, 1090	CONTRL
NX	Total number of discrete elements along the estuary ESTC 190, 260, 560, 600, 890, 950, 1080, 1170 SOLV 280, 390, 520 SOLF 190, 300, 470, 850 BIOC 2760, 2870 ENDC 140, 260, 270 TRPO 360, 490, 550, 1090, 1780 1800, 1890 PLTC 1290, 1510, 1740 OUTP 180, 380, 700, 890, 1090, 1230, 1460 INIT 90, 140 STOR 390, 430, 820, 870 DPLO 860, 1170	CONTRL
NXC	Number of discrete elements plus one imaginary element above and one below (NX+2) ESTC 200, 430, 680, 940, 950 OUTP 260, 950, 1140 DPLO 550, 620, 650	CONTRL
OUTPUT*	Subroutine that is called every NTW'th time step by MAIN to give the specified output MAIN 620, 820, 1110, 1140	

VARIABLE		COMMON
PCRGRW(KP)	Critical population density (number/ft^3) above which the growth rate coefficient decreases linearly with increasing population density of life stage KP BIOC 530, 1640, 3630, 3670	CONGRW
PCRMOB(KP)	Critical population density (number/ft^3) above which the swimming speed decreases linearly with increasing population density of life stage KP BIOC 710, 2480 TRPO 1380, 1420, 2000, 2040	CONMOB
PCRMOR(KP)	Critical population density (number/ft^3) above which the mortality rate coefficient increases linearly with increasing population density of life stage KP BIOC 620, 2010, 3940, 3980	CONMOR
PCRSPW(KP)	Critical population density (number/ft^3) above which the spawning rate decreases linearly with increasing population density of life stage KP BIOC 380, 900, 2960, 3000	CONSPW
PCRSRV(KP)	Critical population density (number/ft^3) above which the apparent survival probability decreases linearly with increasing population density of life stage KP BIOC 440, 1260, 3320, 3360	CONSRV
PDGBED(KP,IX)	Population density (number/ft^3) of life stage KP in the seepage flow at the bed of discrete element IX SOLF 770 TRPO 580	CONBED
PDGSUR(KP)	Population density (number/ft^3) of life stage KP in the surface flow SOLF 760 TRPO 530	CONSUR

VARIABLE		COMMON
PDN(KP,IX)	Population density (number/ft^3) for life stage KP in discrete element IX SOLV 430, 435, 442 SOLF 420, 450, 480, 490, 520 BIOC 2940, 3300 ENDC 190, 200, 260, 270 TRPO 1040, 1180, 1190, 1800, 1890 PLTC 2280, 2400, 2420 TRBC 260 OUTP 910, 1110, 1240, 1470 INIT 100, 150 STOR 830, 900, 910 DPLO 590	PDNSOL
PDNAME (KP,INAME)	Name of life stage KP BIOC 310, 840, 1210, 1580, 1950, 2350 PLTC 530 OUTP 790, 800, 1020, 1030, 1280 DPLO 760, 1070, 1380 TPLO 730, 950, 1150	GROUPS
PDNDNS(KP)	Population density (number/ft^3) for life stage KP in the transect area representing the downstream of the estuary ENDC 220, 260, 290 OUTP 950, 1140	CONEND
PDNDNX(KP)	Downstream population density (number/ft^3) for life stage KP in the imaginary external downstream element SOLF 530 ENDC 230, 270, 280, 300 TRPO 1810, 1890	CONEND
PDNTRB (KP,IITRB)	Population density (number/ft^3) for life stage KP from tributary IITRB TRBC 150, 260	CONTRB
PDNUPS(KP)	Population density (number/ft^3) for life stage KP in the transect area representing the upstream end of the estuary ENDC 200 OUTP 870, 1070	CONEND

VARIABLE		COMMON
PDNUPX(KP)	Upstream population density (number/ft^3) for life stage KP in the imaginary external upstream element SOLF 440 ENDC 190 TRPO 1040	CONEND
PLNAME (IDNPLT,INAME)	Plant name for plant IDNPLT PLTC 270, 970	CONPLT
PLTCON*	Subroutine that reads (and writes) the plant-operational conditions for the desired period and determines the plant's (s') effect on the life-stage population function MAIN 570, 1060 SOLF 840	
PMXGRW(KP)	Maximum population density (number/ft^3) above which the growth rate coefficient is assumed to be zero for life stage KP BIOC 530, 1670, 3660, 3670	CONGRW
PMXMOB(KP)	Maximum population density (number/ft^3) above which the swimming speed is assumed to be zero for life stage KP BIOC 710, 2510 TRPO 1410, 1420, 2030, 2040	CONMOB
PMXMOR(KP)	Maximum population density (number/ft^3) above which the mortality is assumed to be catastrophic for life stage KP BIOC 620, 2040, 3970, 3980	CONMOR
PMXSPW(KP)	Maximum population density (number/ft^3) above which the spawning rate is assumed to be zero for life stage KP BIOC 380, 930, 2990, 3000	CONSPW

VARIABLE		COMMON
PMXSRV(KP)	Maximum population density (number/ft^3) above which the apparent survival probability is assumed to be zero for life stage KP BIOC 440, 1290, 3350, 3360	CONSRV
POBMOB(KP)	Optimum population density (number/ft^3) below which the swimming speed decreases linearly with decreasing population density of life stage KP BIOC 710, 2450 TRPO 1350, 1360, 1970, 1980	CONMOB
PRTEGG(IX)	Egg deposition rate (number/(ft^3 hr)) in discrete element IX SOLF 660, 810 BIOC 2770, 3280, 4260	CONPRT
PRTGRW(KP,IX)	Growth rate (number/(ft^3 hr)) of life stage KP's population into the next life stage in discrete element IX SOLF 680, 700 BIOC 2810, 4280, 4370, 4420	CONPRT
PRTMOR(KP,IX)	Mortality rate (number/(ft^3 hr) of life stage KP's population in discrete element IX SOLF 700 BIOC 2820, 4380, 4430	CONPRT
PRTSPW(KP,IX)	Spawning rate (number/(ft^3 hr)) of life stage KP's population in discrete element IX BIOC 2800, 3230, 3240, 3260	CONPRT
PTRBED(KP,IX)	Transfer flux (number/(ft^2 hr)) of life stage KP's population at the bed of discrete element IX SOLF 780 TRPO 590	CONBED

VARIABLE		COMMON
PTRDEF(KP,IC)	Transfer flux (number/(ft^2 hr)) of life stage KP's population due to convective defect transport across the area of transect IC between the adjacent elements SOLF 730, 740 TRPO 1060, 1230, 1320, 1850, 1940	CONTRP
PTRMIG(KP,IC)	Transfer flux (number/(ft^2 hr)) of life stage KP's population due to migratory transport across the area of transect IC between the adjacent elements SOLF 730, 740 TRPO 1070, 1240, 1710, 1730 1860, 2350, 2370	CONTRP
PTRTID(KP,IC)	Transfer flux (number/(ft^2 hr)) of life stage KP's population due to tidal dispersion across the area of transect IC between the adjacent elements SOLF 730, 740 TRPO 1050, 1220, 1280, 1840, 1900	CONTRP
RCROWD(KP)	Dimensionless weighting parameter for the tendency to move away from crowded conditions for life stage KP TRPO 300, 970, 1690, 2310	CONMIG
RMSHOL(KP)	Dimensionless weighting parameter for shoaling preference of life stage KP TRPO 300, 940, 1670, 2290	CONMIG
ROPGRW(KP)	Optimum (maximum) growth rate coefficient (1/hr) for life stage KP BIOC 530, 1610, 4370	CONGRW
ROPMOR(KP)	Optimum (minimum) mortality rate coefficient (1/hr) for life stage KP BIOC 620, 1980, 4380	CONMOR
ROPSPW(KP)	Optimum spawning rate coefficient (1/hr) for life stage KP BIOC 380, 870, 3230	CONSPW
RSC(IC)	Shoal ratio parameter at transect IC ESTC 250, 400 TRPO 440, 490	GEOCRS

VARIABLE		COMMON
RSH(IX)	Average shoal ratio parameter in discrete element IX ESTC 410 TRPO 440, 490 OUTP 450	GEOELM
SERPDN(KP)	Total discretization error of solution for population density of life stage KP over all discrete elements OUTP 1310, 1360	PUTOUT
SLC(IC)	Salinity (ppp) at transect IC ESTC 1070, 1160, 1250 TRPO 1110, 1770	CONCRS
SLN(IX)	Average salinity (ppp)* in discrete element IX ESTC 1140, 1250 BIOC 2890 PLTC 1950 OUTP 730	CONELM
SLNFAC(IXC)	Salinity correction factor in element IXC ESTC 440, 1140	CONFAC
SLNPER(IPER)	Ocean salinity (ppp) at the Battery for period IPER ESTC 510, 960	CONPER
SMNGRW(KP)	Minimum salinity (ppp) below which growth to the next life stage cannot occur and above which the growth rate coefficient increases with increasing salinity for life stage KP BIOC 550, 1820, 3790, 3810	CONGRW
SMNMOB(KP)	Minimum salinity (ppp) below which the fish has maximum swimming speed and above which the swimming speed decreases with increasing salinity for life stage KP BIOC 740, 2660 TRPO 1550, 1570, 2170, 2190 PLTC 2110, 2130	CONMOB

*NOTE: ppp means parts per part.

VARIABLE		COMMON
SMNMOR(KP)	Minimum salinity (ppp) below which the mortality is assumed to be catastrophic, and above which the mortality rate coefficient decreases with increasing salinity for life stage KP BIOC 640, 2190, 4100, 4120	CONMOR
SMNSPW(KP)	Minimum salinity (ppp) below which spawning does not occur, and above which the spawning rate increases with increasing salinity for life stage KP BIOC 400, 1080, 3120, 3140	CONSPW
SMNSRV(KP)	Minimum salinity (ppp) below which survival to the next life stage is not possible, and above which the apparent survival probability increases with increasing salinity for life stage KP BIOC 460, 1440, 3480, 3500	CONSRV
SMXGRW(KP)	Maximum salinity (ppp) above which growth to the next life stage cannot occur for life stage KP BIOC 550, 1880, 3860, 3870	CONGRW
SMXMOB(KP)	Maximum salinity (ppp) above which the fish has no swimming ability for life stage KP BIOC 740, 2730 TRPO 1620, 1630, 2240, 2250 PLTC 2180, 2190	CONMOB
SMXMOR(KP)	Maximum salinity (ppp) above which the mortality is assumed to be catastrophic for life stage KP BIOC 640, 2270, 4170, 4180	CONMOR
SMXSPW(KP)	Maximum salinity above which spawning does not occur for life stage KP BIOC 400, 1150, 3190, 3200	CONSPW
SMXSRV(KP)	Maximum salinity (ppp) above which survival to the next life stage is not possible for life stage KP BIOC 460, 1510, 3550, 3560	CONSRV

VARIABLE		COMMON
SOHGRW(KP)	Higher salinity bound (ppp) above which the growth rate coefficient decreases, from the optimum value, with increasing salinity for life stage KP BIOC 550, 1860, 3830, 3870	CONGRW
SOHMOB(KP)	Maximum salinity (ppp) above which the fish has maximum swimming speed for life stage KP BIOC 740, 2700 TRPO 1590, 1630, 2210, 2250 PLTC 2150, 2190	CONMOB
SOHMOR(KP)	Higher salinity bound (ppp) above which the mortality rate coefficient increases, from its minimum value, with increasing salinity for life stage KP BIOC 640, 2240, 4140, 4180	CONMOR
SOHSPW(KP)	Higher salinity bound (ppp) above which the spawning rate decreases, from the optimum value, with increasing salinity for life stage KP BIOC 400, 1130 , 3160, 3200	CONSPW
SOHSRV(KP)	Higher salinity bound (ppp) above which the apparent survival probability decreases, from the optimum value, with increasing salinity for life stage KP BIOC 460, 1480, 3520, 3560	CONSRV
SOLFNC*	Subroutine that furnishes SOLVER with updated spawning and life-stage population rates MAIN 540 SOLV 380	
SOLGRW(KP)	Lower salinity bound (ppp) at which the growth rate coefficient attains the optimum value for life stage KP BIOC 550, 1840, 3800, 3810	CONGRW

VARIABLE		COMMON
SOLMOB(KP)	Minimum salinity (ppp) below which the fish has maximum swimming speed, and above which the swimming speed decreases with increasing salinity for life stage KP BIOC 740, 2680 TRPO 1560, 1570, 2180, 2190 PLTC 2120, 2130	CONMOB
SOLMOR(KP)	Lower salinity bound (ppp) at which the mortality rate coefficient attains its minimum value for life stage KP BIOC 640, 2210, 4110, 4120	CONMOR
SOLSPW(KP)	Lower salinity bound (ppp) at which the spawning rate attains the optimum value for life stage KP BIOC 400, 1100, 3130, 3140	CONSPW
SOLSRV(KP)	Lower salinity bound (ppp) at which the apparent survival probability attains the optimum value for life stage KP BIOC 460, 1460, 3490, 3500	CONSRV
SOLVER*	Subroutine that numerically integrates the population differential equations using a fourth order Runge-Kutta-Gill technique MAIN 530, 1080	
STORER*	Subroutine that calculates and stores five-element population averages (every ITAVG days) and calls DPLOTS and TPLOTS to plot the populations OUTPUT 500, 1390, 1420	
T	Present time of calculation (hrs) MAIN 730, 840, 870 SOLVER 370 DPLO 730	CONTRL
THRDAY	Hour of the day MAIN 730, 870, 880, 890 OUTP 550, 1440 INIT 70 DPLO 780, 1090, 1390	DATIME

VARIABLE		COMMON
TIDPER	Tidal period (cycle) in hours TRPO 220, 430, 380, 1670, 1690, 2290, 2310	CONTID
TMC(IC)	Temperature (°F) in cross section IC ESTC 880, 950, 1240 TRPO 1100, 1760	CONCRS
TMNGRW(KP)	Minimum temperature (°F) below which growth to the next life stage cannot occur and above which the growth rate coefficient increases with increasing temperature for life stage KP BIOC 540, 1700, 3690, 3710	CONGRW
TMNMOB(KP)	Minimum temperature (°F) below which the fish has no swimming ability and above which the swimming speed increases with increasing temperature for life stage KP BIOC 730, 2540 TRPO 1440, 1460, 2060, 2080 PLTC 2000, 2020	CONMOB
TMNMOR(KP)	Minimum temperature (°F) below which the mortality is assumed to be catastrophic, and above which the mortality rate coefficient decreases with increasing temperature for life stage KP BIOC 630, 2070, 4000, 4020	CONMOR
TMNSPW(KP)	Minimum temperature (°F) below which spawning does not occur, and above which the spawning rate increases with increasing temperature for life stage KP BIOC 390, 960, 3020, 3040	CONSPW
TMNSRV(KP)	Minimum temperature (°F) below which survival to the next life stage is not possible, and above which the apparent survival probability increases with increasing temperature for life stage KP BIOC 450, 1320, 3380, 3400	CONSRV

VARIABLE		COMMON
TMP(IX)	Average temperature (°F) in discrete element IX ESTC 920, 1240 BIOC 2880 PLTC 1940 OUTP 730	CONELM
TMPFAC(IXC)	Temperature adjustment factor for element IXC ESTC 440, 880, 920, 950	CONFAC
TMPPER(IPER)	Average water temperature (°F) for period IPER (as measured at Verplanck) ESTC 510, 860	CONPER
TMXCND(KP)	Maximum temperature (°F) above which the plant survival probability is assumed to be zero for life stage KP PLTC 330, 680, 2320, 2330	PLTSRV
TMXGRW(KP)	Maximum temperature (°F) above which growth to the next life stage cannot occur for life stage KP BIOC 540, 1790, 3760, 3770	CONGRW
TMXMOB(KP)	Maximum temperature (°F) above which the fish has no swimming ability for life stage KP BIOC 730, 2630 TRPO 1510, 1520, 2130, 2140 PLTC 2070, 2080	CONMOB
TMXMOR(KP)	Maximum temperature (°F) above which the mortality is assumed to be catastrophic for life stage KP BIOC 630, 2160, 4070, 4080	CONMOR
TMXSPW(KP)	Maximum temperature (°F) above which spawning does not occur for life stage KP BIOC 390, 1050, 3090, 3100	CONSPW

VARIABLE		COMMON
TMXSRV(KP)	Maximum temperature (°F) above which survival to the next life stage is not possible for life stage KP BIOC 450, 1410, 3450, 3460	CONSRV
TOHCND(KP)	Critical temperature (°F) above which the plant survival probability decreases linearly, from its optimum value, with increasing temperature for life stage KP PLTC 330, 650, 2290, 2330	PLTSRV
TOHGRW(KP)	Highest temperature bound (°F) above which the growth rate coefficient decreases from the optimum value, with increasing temperature for life stage KP BIOC 540, 1760, 3730, 3770	CONGRW
TOHMOB(KP)	Highest temperature bound (°F) above which the swimming speed decreases, from the maximum speed, with increasing temperature for life stage KP BIOC 730, 2600 TRPO 1480, 1520, 2100, 2140 PLTC 2040, 2080	CONMOB
TOHSPW(KP)	Highest temperature bound (°F) above which the spawning rate decreases, from the optimum value, with increasing temperature for life stage KP BIOC 390, 1020, 3060, 3100	CONSPW
TOHSRV(KP)	Highest temperature bound (°F) above which the apparent survival probability decreases, from the optimum value, with increasing temperature for life stage KP BIOC 450, 1380, 3420, 3460	CONSRV

VARIABLE		COMMON
TOLGRW(KP)	Lowest temperature bound (°F) at which the growth rate coefficient attains the optimum value for life stage KP BIOC 540, 1730, 3700, 3710	CONGRW
TOLMOB(KP)	Lowest temperature bound (°F) at which the fish can swim at maximum speed for life stage KP BIOC 730, 2570 TRPO 1450, 1460, 2070, 2080 PLTC, 2010, 2020	CONMOB
TOLMOR(KP)	Lowest temperature bound (°F) at which the mortality rate coefficient attains its minimum value for life stage KP BIOC 630, 2100, 4010, 4020	CONMOR
TOLSPW(KP)	Lowest temperature bound (F°) at which the spawning rate attains the optimum value for life stage KP BIOC 390, 990, 3030, 3040	CONSPW
TOLSRV(KP)	Lowest temperature bound (°F) at which the apparent survival probability attains the optimum value for life stage KP BIOC 450, 1350, 3390, 3400	CONSRV
TOTPDN(KP)	Total population of life stage KP in all discrete elements in the estuary OUTP 1270, 1280	PUTOUT
TRBCON*	Subroutine that furnishes SOLFNC with the tributary contributions to the life-stage populations MAIN 580 SOLF 830	

VARIABLE		COMMON
TRPORT*	Subroutine that reads (and writes) life-stage transport conditions and calculates the present tidal dispersion transport flux, convective defect transport flux, and migratory transport flux for the overall longitudinal transport phenomenon MAIN 560 SOLF 290	
VELMOB(KP)	Approximate maximum swimming speed (ft/hr) which characterizes the mobility of life stage KP BIOC 710, 2380 TRPO 1660, 2280 PLTC 2240	CONMOB
VLC(IC)	Maximum tidal speed (ft/hr) at transect IC ESTC 550, 660, 680 TRPO 370, 430, 470, 480	CONCRS
VLT(IX)	Approximate maximum tidal speed (ft/hr) in discrete element IX ESTC 580, 660 PLTC 1660, 1760 OUTP 720	CONELM
VLXTID(IXC)	Maximum tidal speed (ft/hr) for transect IXC (initially read as ft/sec) ESTC 440, 470, 580, 680	CONFAC
X(IX)	Representative location (ft) of discrete element IX (midway between its enclosure transects) with the dam at Troy as the origin ESTC 310, 110 PLTC 1650, 1750 OUTP 240, 440, 730	GEOELM
XC(IC)	Location (ft) of transect IC with the dam at Troy as the origin ESTC 220, 290, 310, 1060 OUTP 200, 210	GEOCRS

VARIABLE		COMMON
XMP(IXC)	Distance in miles from node IXC to the Battery OUTP 210, 245, 260, 870, 910 950, 1070, 1110, 1140 DPLO 580, 610, 620	PUTOUT

GLOSSARY OF INTERMEDIATE VARIABLES NOT PASSED BY COMMON

ACRDIS — Average cross-sectional area (ft^2) in the discrete element containing the discharge from the power plant
PLTC 1930, 2410

ACRIII — Average cross-sectional area (ft^2) of two adjacent transects (equals ACR(IX))
ESTC 320, 330
SOLF 340, 710, 750, 760, 770, 810
OUTP 410, 420, 430, 440

ACRIMH — Cross-sectional area (ft^2) of the upstream transect of a discrete element
SOLF 350, 750

ACRINT — Average cross-sectional area (ft^2) in the discrete element containing the intake of the power plant
PLTC 1910, 2390

ACRIPH — Cross-sectional area (ft^2) of the downstream transect of a discrete element
SOLF 360, 750

ACRTRB — Average cross-sectional area (ft^2) in the discrete element in which the tributary joins the estuary
TRBC 230, 250

B — Freshwater flow parameter used in evaluating the approximate salinity distribution in the estuary (ft/sec)
ESTC 1040, 1050, 1110

BCRIII — Average width (ft) in a discrete element $(\frac{ACR(IX)}{DHB(IX)})$
OUTP 430, 450

BSRIII — Average surface width (ft) of two adjacent transects (equals BSR(IX))
ESTC 360, 370, 410
SOLF 370, 760

CCCDEF — Convection defect transport coefficient (specified)
TRPO 250, 280

CCROWD(IC) — Crowding potential for migration through transect IC
TRPO 200, 350, 450, 500, 1690, 2310

CCSHOL(IC) — Shoaling potential for migration through transect IC
TRPO 200, 340, 440, 490, 1670, 2290

CEXDDN — Variable used as the exponent for calculating the approximate excess temperature distribution downstream from the discharge of the power plant
PLTC 1790-1800, 1810

CEXDUP — Variable used as the exponent for calculating the approximate excess temperature distribution upstream from the discharge of the power plant
PLTC 1690-1700, 1710

CMXMOR — Value of the mortality rate coefficient used in the population density correction factor for mortality to represent catastrophic mortality conditions (specified)
BIOC 270, 3980, 4020, 4080, 4120, 4180, 4220

CORDIS — Population density correction factor for a life stage surviving the cooling loop in the power plant
PLTC 2370, 2380

CORGRW — Correction factor for growth determined by the temperature and salinity conditions in the estuary on the potential growing population
BIOC 3890, 3910, 4370

CORINT — Population density correction factor for a life stage not able to escape the intake of the power plant
PLTC 2270, 2280

CORMOB — Correction factor for mobility determined by the temperature and salinity conditions in the estuary on the potential mobile population
TRPO 1650, 1660, 2270, 2280
PLTC 2210, 2240, 2250, 2270

CORMOR — Correction factor for mortality determined by the temperature and salinity conditions in the estuary on the potential dying population
BIOC 4200, 4220, 4230, 4380

CORPDN — Population density correction factor determined by biological and mobility characteristics of the life stage (in BIOCON and TRPORT) and also specified and used for scaling the initial distributions (in INITAL) for convenience of generating different population density initial data sets from a common distribution
BIOC 2970, 3000, 3220, 3330, 3360, 3580, 3640, 3670 3890, 3950, 3980, 4200
TRPO 1360, 1390, 1420, 1650, 1980, 2010, 2040, 2270
INIT 130, 150

CORSLN — Correction factor for (survival) growth and death rates determined by salinity conditions in the estuary in conjunction with innate life-stage characteristics
BIOC 3140, 3170, 3200, 3220, 3500, 3530, 3560, 3580, 3810, 3840, 3870, 3890, 4120, 4150, 4180, 4200
TRPO 1540, 1570, 1600, 1630, 1650, 2160, 2190, 2220, 2250, 2270
PLTC 2100, 2130, 2160, 2190, 2240

CORSPW — Correction factor for life-stage spawning rates determined by temperature and salinity conditions in the estuary
BIOC 3220, 3230

CORSRV — Overall correction factor for life-stage survival determined by innate biological characteristics and temperature and salinity conditions of the estuary
BIOC 3580, 3600, 4370, 4380

CORTMP — Correction factor due to temperature effects for spawning rates, survival probabilities, growth rates, mortality rates, and mobility rate coefficients (swimming speed) determined by innate biological characteristics and estuary temperature
BIOC 3040, 3070, 3100, 3220, 3400, 3430, 3460, 3580, 3710, 3740, 3770, 3890, 4020, 4050, 4080, 4200
TRPO 1460, 1490, 1520, 1650, 2080, 2110, 2140, 2270
PLTC 2020, 2050, 2080, 2240, 2300, 2330, 2350, 2370

CTRDEF — Convective defect transport coefficient used to calculate convective defect transport fluxes (PTRDEF(KP,IC))
TRPO 280, 1320, 1940

DAYNDT — Day number since the beginning of the calculations
MAIN 860, 870

DHBDDN — Average maximum channel depth (ft) in a discrete element downstream from the element containing the discharge from the power plant
PLTC 1780, 1800

DHBDUP — Average maximum channel depth (ft) in a discrete element upstream from the element containing the discharge from the power plant
PLTC 1680, 1700

DHBIII — Average maximum channel depth (ft) between two adjacent transects (same as DHB(IX))
ESTC 340, 350, 410
OUTP 400, 430, 440

DISDIL — A factor for the near-field dilution effects for the power plants (specified)
PLTC 220, 1590

DISTMP — Temperature dilution factor according to the ratio of the discharge flow rate to the flow rate in the estuary for the calculation of the approximate excess temperature distribution due to plant operation
PLTC 1590, 1610, 1710, 1810

DNSIPH — Half-point number indicating the downstream end of the estuary
OUTP 190, 950, 1140

DNX — Total number of discrete elements represented as a real number
OUTP 180, 190

DT — Time step (hrs) used in the integration scheme (passed in the argument list)
MAIN 780, 870, 1080
SOLVER 10, 370, 410, 460

DTHR — Time step (hrs) (same as DT)
MAIN 740, 780

DXDENM — Longitudinal length (ft) of two adjacent discrete elements
ESTC 650, 660, 1220, 1230-1250
TRPO 420, 440, 1160, 1200, 1270, 1690, 1780, 1890, 2310

DXDIS — Longitudinal length (ft) of the discrete element containing the discharge from the power plant
PLTC 1920, 2410

DXICMH — Longitudinal length (ft) of the upstream component of DXDENM
TRPO 400, 420, 1140, 1160, 1200

DXICM1 — Longitudinal length (ft) of the upstream component of DXDENM (same as DXICMH in subroutine TRPORT)
ESTC 630, 650, 660, 1200, 1220-1250

DXICPH — Longitudinal length (ft) of the downstream component of DXDENM
TRPO 410, 420, 1150, 1160, 1200

DXICP1 — Longitudinal length (ft) of the downstream component of DXDENM (same as DXICPH in TRPORT)
ESTC 640, 650-660, 1210, 1220-1250

DXIII — Length (ft) between two adjacent transects (same as DX(IX))
ESTC 290, 300-310
SOLF 330, 710, 750, 810
OUTP 390, 420, 440

DXINT — Longitudinal length (ft) of the discrete element containing the intake of a power plant
PLTC 1900, 2390

DXTRB — Longitudinal length (ft) of the discrete element in which the selected tributary joins the estuary
TRBC 220, 250

EGGPRT — Egg production rate (number/(ft^3 hr)) in a discrete element (same as PRTEGG(IX))
BIOC 2900, 3240, 3280

ETAREA — Parameter representing geometrical factors in the calculation of the approximate salinity distribution in the estuary (specified)
ESTC 160, 1040

ETRDDN — Variable representing the tidal dispersion parameter for calculating the approximate excess temperature distribution downstream from the discharge of a power plant
PLTC 1760, 1790

ETRDUP — Variable representing the tidal dispersion parameter for calculating the approximate excess temperature distribution upstream from the discharge of a power plant
PLTC 1660, 1690

ETRTID(IC) — Tidal dispersion coefficient on enclosure surface (transect) IC based on the tidal flow conditions
TRPO 200, 330, 370, 470, 1040, 1270, 1890

EXPINT — Value of exponential used in calculating salinity distribution in the estuary based on intrusion distance
ESTC 1050, 1120

EXPXFT — Value of exponential containing the distance from the ocean end used in calculating salinity distribution in the estuary based on intrusion distance
ESTC 1110, 1120

FNCBED — Net rate of change of population density in a discrete element due to population transport from the hypothetical bed layer (number/ft^3 hr)
SOLF 770, 790

FNCCNV — Net time rate of change in an element due to convective transfer of life-stage populations (number/ft^3 hr)
SOLF 710, 790

FNCPRT — Net time rate of life-stage population (number/ft^3 hr) due to birth or growth, death, and growth into the next life stage
SOLF 700, 790

FNCSUR — Net rate of change of population density in a discrete element due to surface effects (e.g., rainfall, etc.)
SOLF 760, 790

FNCTRP — Net time rate of life-stage population density transport into a discrete element (number/ft^3 hr) due to the overall nonconvective longitudinal transport
SOLF 750, 790

GFRCFS — Average freshwater flow rate through a discrete element (c.f.s.)
ESTC 970, 980, 990, 1010, 1040
OUTP 710, 730

GFREST — The freshwater flow rate (ft^3/hr) for period IPER at Green Island (same as GFRPER(IPER)) which is later modified by the appropriate segment flow rate constant to approximate the flow rate in the selected discrete element
ESTC 850, 910, 940, 970

GFRIMH — Freshwater flow rate (ft^3/hr) across the upstream transect of a discrete element
SOLF 390, 550, 710

GFRIPH — Freshwater flow rate (ft^3/hr) across the downstream transect of a discrete element
SOLF 400, 600, 720

GFSDIS — Discharge flow rate from the power plant (ft^3/sec) (same as GFLDIS(IOPPER,IPLANT)/3600)
PLTC 1180, 1190, 1200

GFSINT — Intake flow rate of the power plant (ft^3/sec) (same as GFLINT(IOPPER,IPLANT)/3600)
PLTC 1060, 1070, 1080

GMRIII — Average bed contour (ft) of two adjacent transects (same as GMR(IX))
ESTC 380, 390
SOLF 380, 770

IC — Index denoting transect number from Troy
ESTC 210, 220, 600, 610, 620, 660, 1170, 1180-1190 1230-1250
TRPO 360, 370-390, 430-540, 1090, 1100-1130, 1220-1240 1270-1280, 1300, 1320, 1670, 1690, 1710, 1730

ICIMH — Index describing the upstream transect in a two-transect calculation
ESTC 270, 290, 310-320, 340, 360, 380
SOLF 310, 350, 390, 730

ICIPH — Index describing the downstream transect in a two-transect calculation
ESTC 180, 290, 320, 340, 360, 380, 400
SOLF 320, 360, 400, 740

IDNPLT — Index used to number each plant
PLTC 260, 270-290, 960, 970-980, 1000, 1020, 1040, 1070, 1120, 1140, 1160, 1190, 1570, 1580, 1870, 1880-1890, 1960-1970

IITRB — Index used to number each tributary
TRBC 200, 210, 260

IM — Index used to indicate which month
MAIN 680, 690

INAME — Index used to reference names (of months, life stages, and power plants)
MAIN 480
BIOC 310, 840, 1210, 1580, 1950, 2350
TRPO 790, 910
PLTC 270, 530, 970
OUTP 560, 1280

IOPPER — Index used to number plant-operational time periods
PLTC 380, 390, 410-420, 440-450, 790, 810, 890-900, 930-940, 960, 1060, 1180, 1240, 1380, 1390, 1450 1460, 1490, 1570, 1590-1600, 1870, 1960-1970, 2400, 2420

IPLANT — Index used to number the plants operating during a specified period
PLTC 430, 440-450, 950, 960-970, 1060, 1180, 1240 1560, 1570, 1590-1600, 1860, 1870, 1960, 2270, 2370, 2400, 2420

IPLFNC — Argument to subroutine PLTCON that is used to indicate when plants are operating
PLTC 10, 1360

IT — Index used to ensure that the specified number of time steps (NT) are employed in the calculation phase
MAIN 830

ITW — Index used to determine when to call subroutine OUTPUT in the computational phase
MAIN 790, 850, 1090, 1100

IX — Index used to denote the number of the discrete element from Troy
ESTC 260, 270-28-, 300-310, 330, 350, 370, 390, 410, 560, 570-580, 890, 900-920, 1080, 1090-1100, 1140
SOLV 280, 300, 320, 390, 410-440, 460, 490, 520, 540
SOLF 190, 210, 230, 300, 310-340, 370-380, 420-430, 450, 470-490, 520, 660, 680, 700, 770-790, 810, 850, 860
BIOC 2760, 2770, 2790-2820, 2870, 2880-2890, 2940 3230-3240, 3260, 3280, 3300, 4260, 4280, 4310, 4330, 4350-4380, 4410-4430
TRPO 550, 560, 580-590
PLTC 1290, 1300, 1510, 1520
OUTP 230, 240, 360-370, 380, 390-410, 450-460, 680-690, 700, 710-730, 840-850, 890, 900-910, 930, 1060, 1090, 1100-1110, 1230, 1240-1250, 1460-1470.
INIT 90, 100, 140, 150

IXC — Index denoting element number from Troy, including an external upstream and downstream element (UPSIMH, NX discrete elements, NX + DNSIMH -- in total, NX + 2 elements)
ESTC 430, 440, 460, 570, 580, 900, 910-920, 1090, 1140
OUTP 220, 230-240, 900, 910, 1100, 1110

IXCMH — Index used to denote the upstream element in calculations using two adjacent discrete elements
TRPO 380, 400, 440, 1120, 1140, 1180

IXCPH — Index used to denote the downstream element in calculations using two adjacent discrete elements
TRPO 390, 410, 440, 1130, 1150, 1190

IXD — Index used to signify elements away from the discrete element containing the discharge from the power plant
PLTC 1620, 1630, 1730

IXDIS — Discrete element number (index) containing the discharge from the power plant
PLTC 1580, 1590, 1610, 1630, 1650, 1730, 1750, 1890 1920-1930, 2410-2420

IXDN — Index used to denote elements downstream from the discrete element containing the discharge from the power plant
PLTC 1730, 1740-1780, 1810

IXICM1 — Index used to denote the upstream element adjacent to a specified cross-sectional transect IC
ESTC 610, 630, 660, 1180, 1200, 1230-1250

IXICP1 — Index used to denote the downstream element adjacent to a specified cross-sectional transect IC
ESTC 620, 640, 1190, 1210, 1230-1250

IXINT — Discrete element number (index) containing the intake for a power plant
PLTC 1880, 1900-1910, 1940-1950, 2280, 2390-2400

IXTRB — Index number used to denote the discrete element in which the tributary joins the estuary
TRBC 210, 220-230, 250-260

IXUP — Index used to denote discrete elements upstream from the discrete element containing the discharge from the power plant
PLTC 1630, 1640-1680, 1710

KP — Index used to denote which life stage
SOLV 290, 300, 400, 410, 420, 430, 435, 440, 442, 443
SOLF 200, 210, 410, 420, 440, 450, 480, 490, 520, 530, 650, 680, 700, 730, 740, 760, 770, 780, 790
BIOC 300, 310, 340, 360, 370, 380, 390, 400, 430, 440, 450, 460, 490, 510, 520, 530, 540, 550, 580, 600, 610, 620, 630, 640, 670, 690, 700, 710, 730, 740, 820, 830, 840, 850, 870, 900, 930, 960, 990, 1020, 1050, 1080, 1100, 1120, 1150, 1200, 1210, 1220, 1240, 1260, 1290, 1320, 1350, 1380, 1410, 1440, 1460, 1480, 1510, 1560, 1570, 1580, 1590, 1610, 1640, 1670, 1700, 1730, 1760, 1790, 1820, 1840, 1860, 1880, 1930, 1940, 1950, 1960, 1980, 2010, 2040, 2070, 2100, 2130, 2160, 2190, 2210, 2240, 2270, 2330, 2340, 2350, 2360, 2380, 2420, 2450, 2480, 2510, 2540, 2570, 2600, 2630, 2660, 2680, 2700, 2730, 2780, 2790, 2800, 2810, 2820, 2920, 2930, 2940, 2960, 2990, 3000, 3020, 3030, 3040, 3060, 3090, 3100, 3120, 3130, 3140, 3160, 3190, 3200, 3230, 3240, 3260, 3290, 3300, 3320, 3350, 3360, 3380, 3390, 3400, 3420, 3450, 3460, 3480, 3490, 3500, 3520, 3550, 3560, 3620, 3630, 3660, 3670, 3690, 3700, 3710, 3730, 3760, 3770, 3790, 3800, 3810, 3830, 3860, 3870, 3930, 3940, 3970, 3980, 4000, 4010, 4020, 4040, 4070, 4080, 4100, 4110, 4120, 4140, 4170, 4180, 4230, 4250, 4280, 4310, 4330, 4350, 4360, 4370, 4380, 4410, 4420, 4430

ENDC 110, 120, 180, 190, 200, 220, 230, 260, 270, 280, 290, 300
TRPO 290, 300, 520, 530, 570, 580, 590, 780, 790, 820, 890, 900, 910, 940, 970, 1030, 1040, 1050, 1060, 1070, 1170, 1180, 1190, 1220, 1230, 1240, 1280, 1320, 1330, 1340, 1350, 1360, 1380, 1410, 1420, 1440, 1450, 1460, 1480, 1510, 1520, 1550, 1560, 1590, 1620, 1630, 1660, 1670, 1690, 1710, 1730, 1790, 1800, 1810, 1840, 1850, 1860, 1890, 1900, 1940, 1950, 1960, 1970, 1980, 2000, 2030, 2040, 2060, 2070, 2080, 2100, 2130, 2140, 2170, 2180, 2190, 2210, 2240, 2250, 2280, 2290, 2310, 2350, 2370
PLTC 320, 330, 520, 530, 550, 590, 620, 650, 680 1980, 1990, 2000, 2010, 2020, 2040, 2070, 2080, 2110, 2120, 2130, 2150, 2180, 2190, 2240, 2270, 2280, 2290, 2320, 2330, 2380, 2390, 2400, 2410, 2420
TRBC 140, 150, 240, 250, 260
OUTP 790, 800, 830, 870, 910, 950, 1020, 1030, 1050, 1070, 1110, 1140, 1200, 1240, 1250, 1270, 1280, 1310, 1360, 1470
INTI 100

MNODAY — Day number at the start of the plant-operational period
PLTC 750, 800, 850, 860, 890

MNYEAR — Year number at the start of the plant-operational period
PLTC 360, 780, 870, 890, 910

MXODAY — Day number at the end of the plant-operational period
PLTC 760, 800-820, 830, 890

MXYEAR — Year number at the end of the plant-operational period
PLTC 780, 840, 890

NDATAT — Number of days for which period-averaged estuary data is given
ESTC 690, 720, 740, 750, 810, 1280

NDTDAY — The number of the day since the start of the computational scheme
MAIN 800, 860, 900

NDYEAR — Number of days in the year
PLTC 770, 820-830, 850-860

NPER — Number of periods for which estuary input data exist
ESTC 480, 500, 730

NPLAST — Index of the last life stage whose conditions are written whenever subroutine OUTPUT is called (if IWRITE > 0)
OUTP 990, 1000, 1010, 1030, 1070, 1110, 1140-1150

NPLDAY — Number of days for which plant operational data are given
PLTC 1320, 1370, 1390, 1400, 1440, 1460, 2460, 2490

NPSTRT — Index of the first life stage whose conditions are written whenever subroutine OUTPUT is called (if IWRITE > 0)
OUTP 970, 980, 990, 1030, 1050, 1070, 1110, 1140

NTOTHR — Total number of time steps used in the computational phase (same as NT)
MAIN 740, 760

PCROWD — Crowding factor (number/ft^2 hr) in the transfer flux term PTRMIG(KP,IC)
TRPO 1700, 1710, 2320, 2330

PCSHOL — Shoaling factor (number/ft^2 hr) in the transfer flux term PTRMIG(KP,IC)
TRPO 1680, 1710, 2300, 2330

PDNDIS — Corrected population density (number/ft^3) of the life stage in the discrete element containing discharge from a power plant
PLTC 2380, 2420

PDNGRW — Potential growing population (number/ft^3) of the life stage in a discrete element
BIOC 4350, 4370

PDNICH — Average life-stage population density (number/ft^3) of two adjacent discrete elements
TRPO 1200, 1210, 1350-1360, 1380, 1410-1420, 1680, 1820, 1830, 1970-1980, 2000, 2030-2040, 2300

PDNICM — Life-stage population density (number/ft^3) in the upstream element of two adjacent discrete elements
TRPO 1180, 1200, 1270, 1290, 1700, 1800, 1820, 1910, 2320

PDNICP — Life-stage population density (number/ft^3) in the downstream element of two adjacent discrete elements
TRPO 1190, 1200, 1270, 1310, 1700, 1810, 1820, 1930, 2320

PDNIII — Life-stage population density (number/ft^3) (same as PDN(KP,IX))
SOLF 420, 560, 610, 710-720, 760-770
BIOC 2940, 2950-2960, 2990-3000, 3230, 3300-3320 3350-3360, 3660-3670, 3940, 3970-3980, 4310, 4330

PDNIM1 — The life-stage population density (number/ft^3) in the adjacent discrete element upstream from a specified discrete element
SOLF 440, 480, 520, 580

PDNINT — Corrected population density (number/ft^3) of the life stage in the discrete element containing the intake from a power plant
PLTC 2280, 2380, 2400

PDNIP1 — The life-stage population density (number/ft^3) in the adjacent discrete element downstream from a specified discrete element
SOLF 450, 490, 530, 630

PDNMIN — Specified population density limit (number/ft^3) (> 0) used in the Runge-Kutta-Gill scheme (if PDN(KP,IX) $\leq$ PDNMIN, PDN(KP,IX) is equated to 0.)
SOLV 70, 540

PDNMOR — Potential dying population (number/ft^3) of the life stage in a discrete element
BIOC 4360, 4380

PDNTCH — Population density (number/ft^3) of a life stage crossing the area of a specified cross-sectional IC defined according to upwind differencing techniques
TRPO 1290, 1310, 1320, 1910, 1930, 1970

PDNTMH — Population density (number/ft^3) of a life stage crossing the upstream surface of a specified discrete element defined according to upwind differencing conditions
SOLF 560, 580, 710

PDNTPH — Population density (number/ft^3) of a life stage crossing the downstream surface of a specified discrete element defined according to upwind differencing conditions
SOLF 610, 630, 720

PRTGEN — Generation rate (number/ft^3 hr) of a life stage directly due to spawning or due to the growth of a younger life stage into the life stage
SOLF 660, 680, 700
BIOC 4260, 4280, 4300

PTRIMH — Overall nonconvective longitudinal transport rate (number/ft^3 hr) of a life-stage population density across the upstream transect area of a discrete element
SOLF 730, 750

PTRIPH — Overall nonconvective longitudinal transport rate (number/ft^3 hr) of a life-stage population density across the downstream transect area of a discrete element
SOLF 740, 750

PTRTRB — Transport flux (number/ft^2 hr) due to tidal dispersion (same as PTRTID(KP,IC))
TRPO 1040, 1050, 1270, 1280, 1890, 1900

SLNICH — Salinity (ppp) across transect area at IC (same as SLC(IC))
TRPO 1110, 1550-1570, 1590, 1620-1630, 1770, 2170-2190, 2210, 2240-2250

SLNIII — Local salinity (ppp) in the discrete element (same as SLN(IX))
ESTC 1120, 1130, 1140
BIOC 2890, 3120-3140, 3160, 3190, 3200, 3480-3490, 3500, 3520, 3500-3560, 3790-3810, 3830, 3860-3870, 4100-4120, 4140, 4170-4180

SLNINT — Salt front value based on salinity intrusion assumption (specified)
ESTC 150, 1120, 1130

SLNINT — Salinity (ppp) in the discrete element containing the intake of the power plant
PLTC 1950, 2110-2130, 2150, 2180-2190

SLNOCN — Salinity (ppp) of the ocean at the Battery
ESTC 960, 1120, 1160

SUMERR — Sum of local truncation errors for the population density over all discrete elements
OUTP 1220, 1250, 1310

SUMPDN — Total standing crop of a life stage over all discrete elements
OUTP 1210, 1240, 1270

TMPDIS — Temperature (°F) of the discharge effluent from the power plant
PLTC 1970, 2290, 2320-2330

TMPEST — Average water temperature (°F) for the given period as measured at Verplanck (same as TMPPER(IPER))
ESTC 860, 880, 920, 950

TMPICH — Temperature (°F) in the given cross section (same as TMC(IC))
TRPO 1100, 1440-1460, 1480, 1510-1520, 1760, 2060-2080, 2110, 2130-2140

TMPIII — Average temperature (°F) in the given discrete element (same as TMP(IX))
BIOC 2880, 3020-3040, 3060, 3090-3100, 3380-3400, 3420, 3450-3460, 3690-3710, 3730, 3760, 4000-4020, 4040, 4070-4080

TMPINT — Average temperature (°F) in the discrete element containing the intake of the power plant (same as TMP(IXINT))
PLTC 1940, 1970, 2000-2020, 2040, 2070-2080

TOTEGG — Total number of eggs spawned in all elements in the estuary
OUTP 860, 930, 1170

TS — The lower time limit of integration (hrs) of each step of the Runge-Kutta-Gill method (passed in the argument list)
MAIN 840, 1080
SOLV 10, 370

UPSIMH — Half-point number indicating the upstream end of the estuary
OUTP 170, 870, 1070

VCROWD — Crowding rate (1/hr) of a life stage
TRPO 1690, 1700, 2310, 2320

VCSHOL — Shoaling rate (1/hr) of a life stage
TRPO 1670, 1680, 2290, 2310

VELINT — Intake velocity (ft/hr) at the intake of the power plant
PLTC 1960, 2240

VFCTCH — Freshwater velocity (ft/hr) across a transect area
TRPO 1300, 1310-1320, 1920, 1930-1940

VFSMOB — Approximate maximum swimming speed (ft/sec) which characterizes a life stage (VELMOB(KP)/3600)
BIOC 2380, 2390

VLXMOB — Maximum swimming speed (ft/hr) corrected for salinity and temperature conditions and innate biological characteristics of the life stage
TRPO 1660, 1670, 1690, 2280, 2290, 2310

XFTIII — Distance (ft) of a discrete element from the Battery
ESTC 1100, 1110

XFTINT — Dimensionless salt intrusion length
ESTC 1030, 1050

XLTEST — Total length (ft) of the estuary considered in the model
ESTC 1060, 1110

XLXTID — Tidal excursion length in the element
TRPO 430, 440, 450, 480, 490, 500

XMLINT — Empirical salinity intrusion length used in the calculations of approximate salinity distribution in the estuary
ESTC 990, 1010, 1030

XMPBAT — Location of the Battery (ft) with the dam at Troy as the origin (same as XC(NC))
OUTP 200, 210, 240

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APPENDIX B. ADDITIONAL OUTPUT SUBROUTINES

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Description of Additional Output Subroutines

Subroutines STORER, DPLOTS, and TPLOTS did not belong to the original computer code, but they have been added to expand the types of output from computer runs.

STORER

Subroutine STORER is the driving program for additional output (Fig. B.1). If flag ISTORE is greater than 0, subroutine OUTPUT calls STORER once in the initialization phase (KRUN = 0), once every time the main program calls OUTPUT in the computational phase (KRUN = 1), and once in the special output phase (KRUN = 2). In the initialization phase, variables that are used in later operations are defined in STORER. With KRUN = 1, STORER may make plots of instantaneous densities (PDN(KP,IX)), calculates, writes, and may plot (see DPLOTS) five-element-averaged densities and standing crops for each life stage KP, segment IXSEG, and period (week), ITAVG (PDNAVG(KP, IXSEG,ITABG)),PNNAVG(KP,IXSEG,ITAVG). Table B.1 describes the location of each of the fifteen segments.

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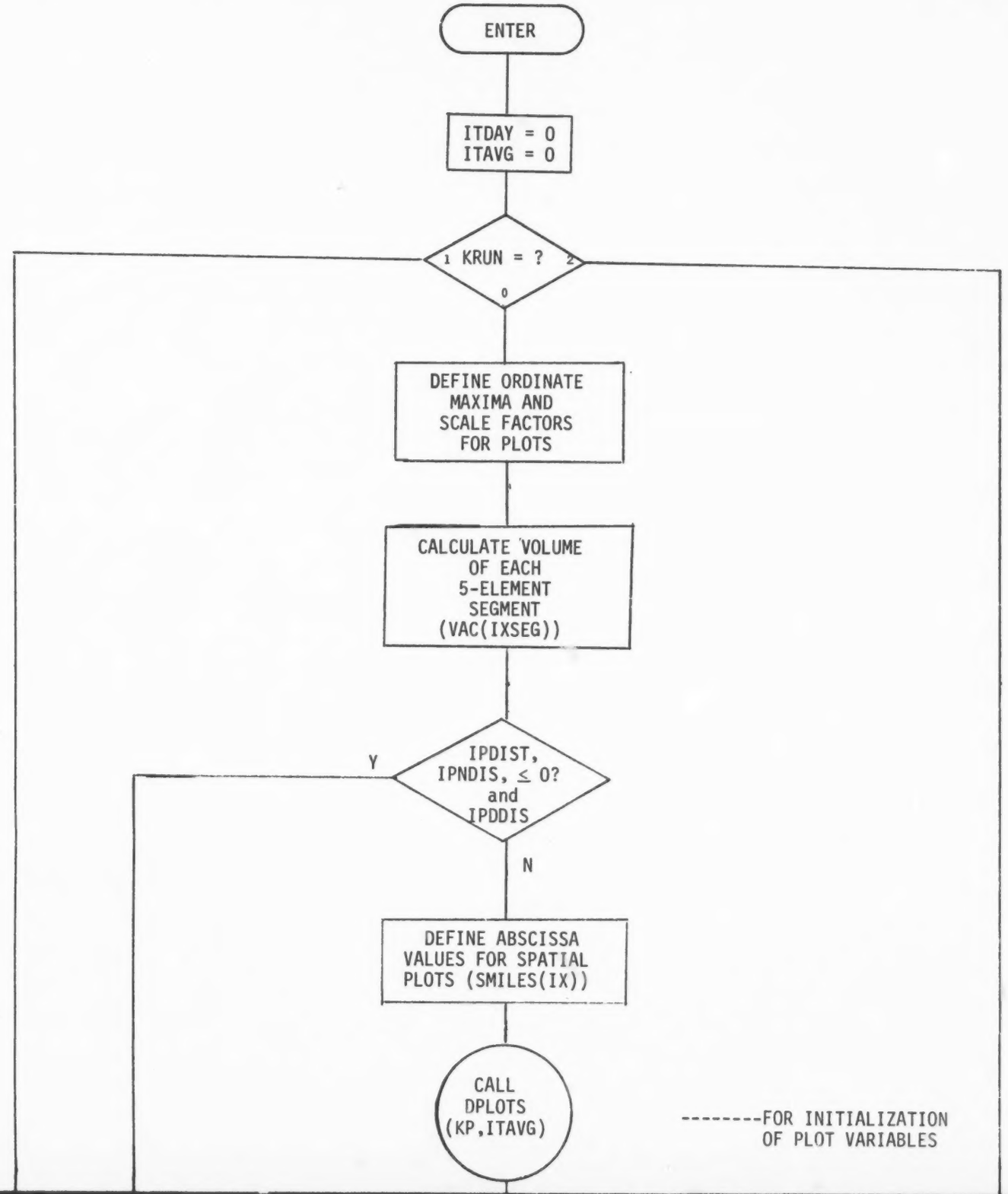

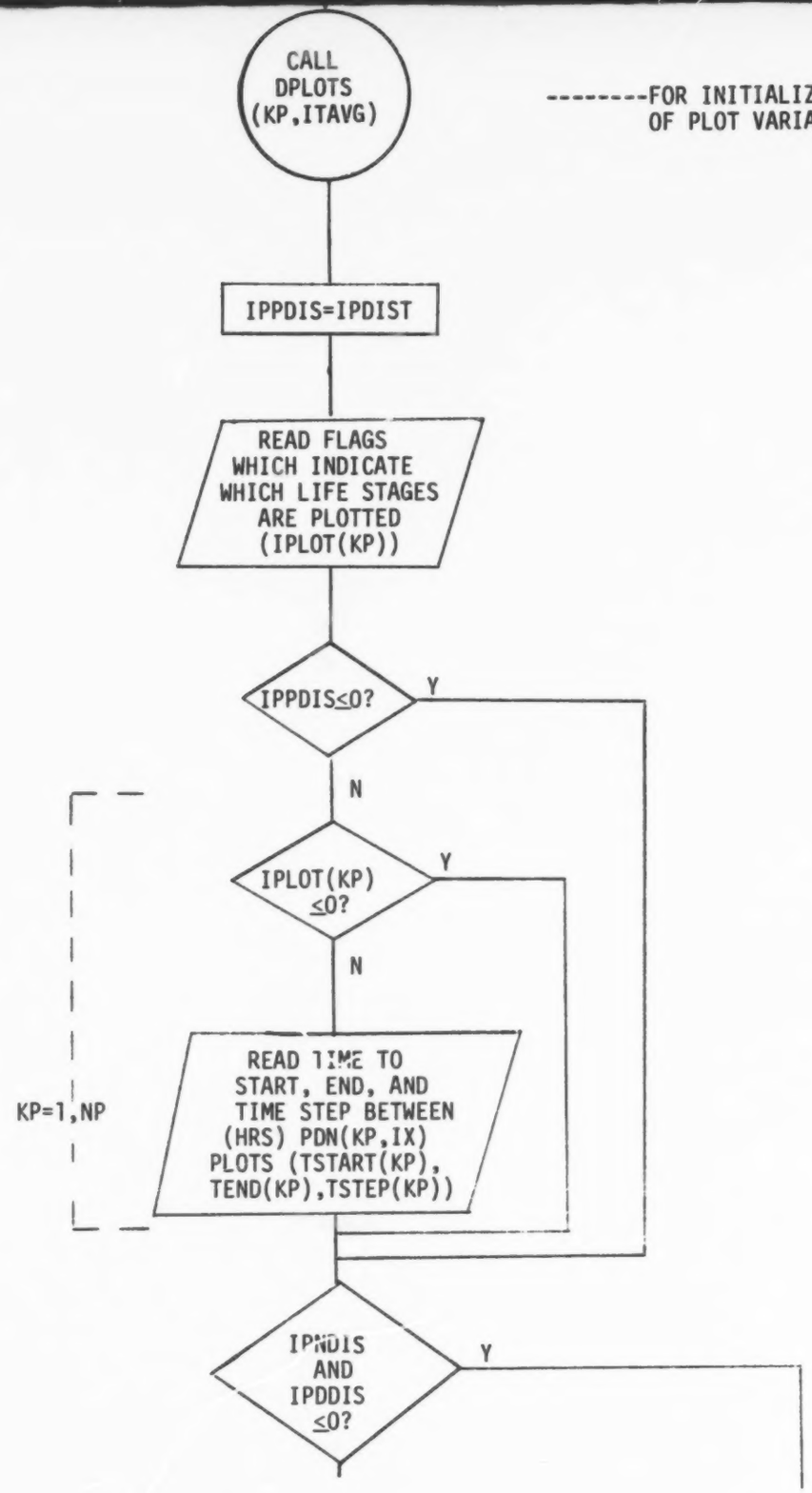

Figure B.1. Abridged flow chart of subroutine STORER

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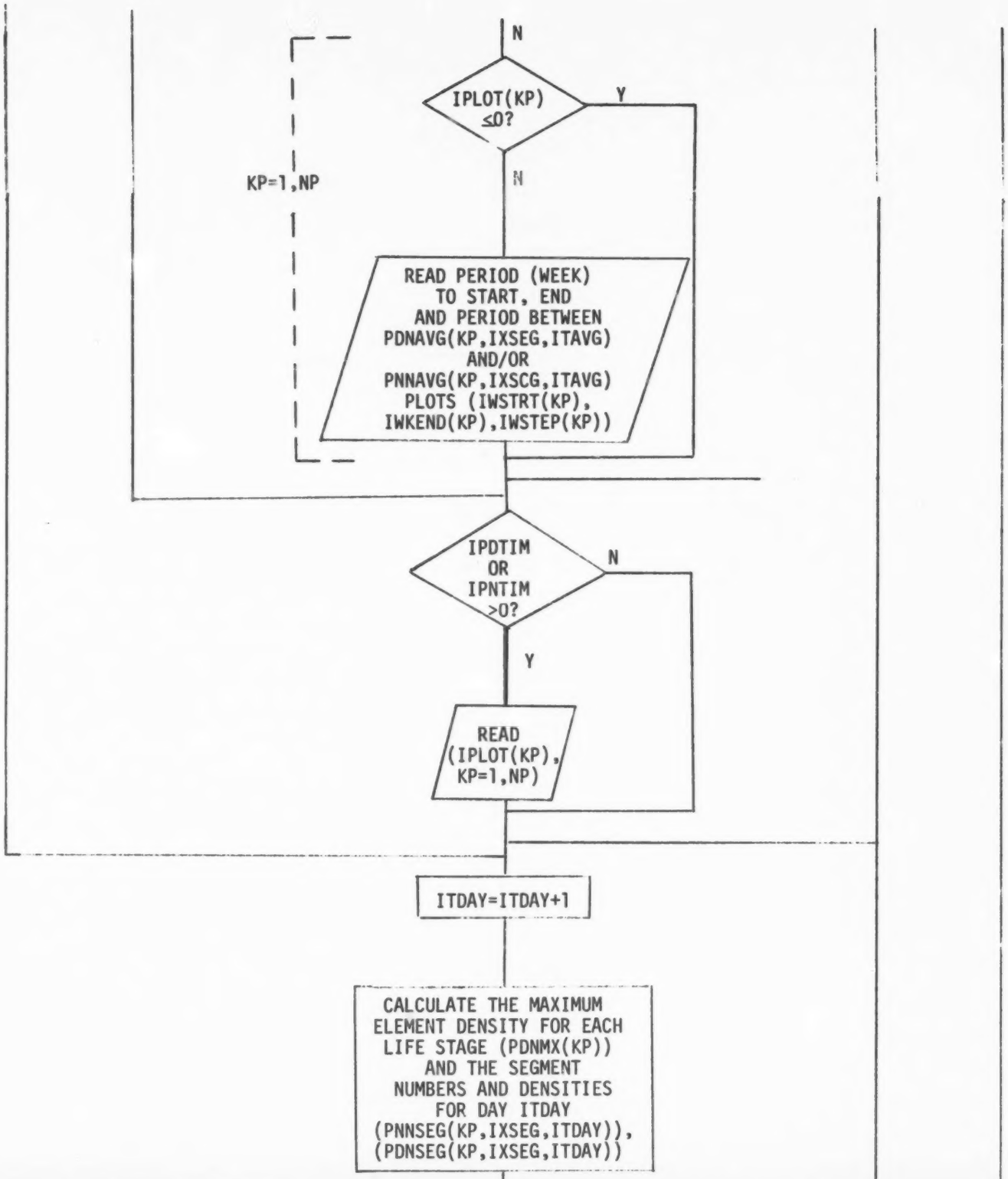
KP=1,NP
IPLOT(KP) ≤0?
N
Y
N
READ PERIOD (WEEK) TO START, END AND PERIOD BETWEEN PDNAVG(KP,IXSEG,ITAVG) AND/OR PNNAVG(KP,IXSCG,ITAVG) PLOTS (IWSTRT(KP), IWKEND(KP),IWSTEP(KP))
IPDTIM OR IPNTIM >0?
N
Y
READ (IPLOT(KP), KP=1,NP)
ITDAY=ITDAY+1
CALCULATE THE MAXIMUM ELEMENT DENSITY FOR EACH LIFE STAGE (PDNMX(KP)) AND THE SEGMENT NUMBERS AND DENSITIES FOR DAY ITDAY (PNNSEG(KP,IXSEG,ITDAY)), (PDNSEG(KP,IXSEG,ITDAY))

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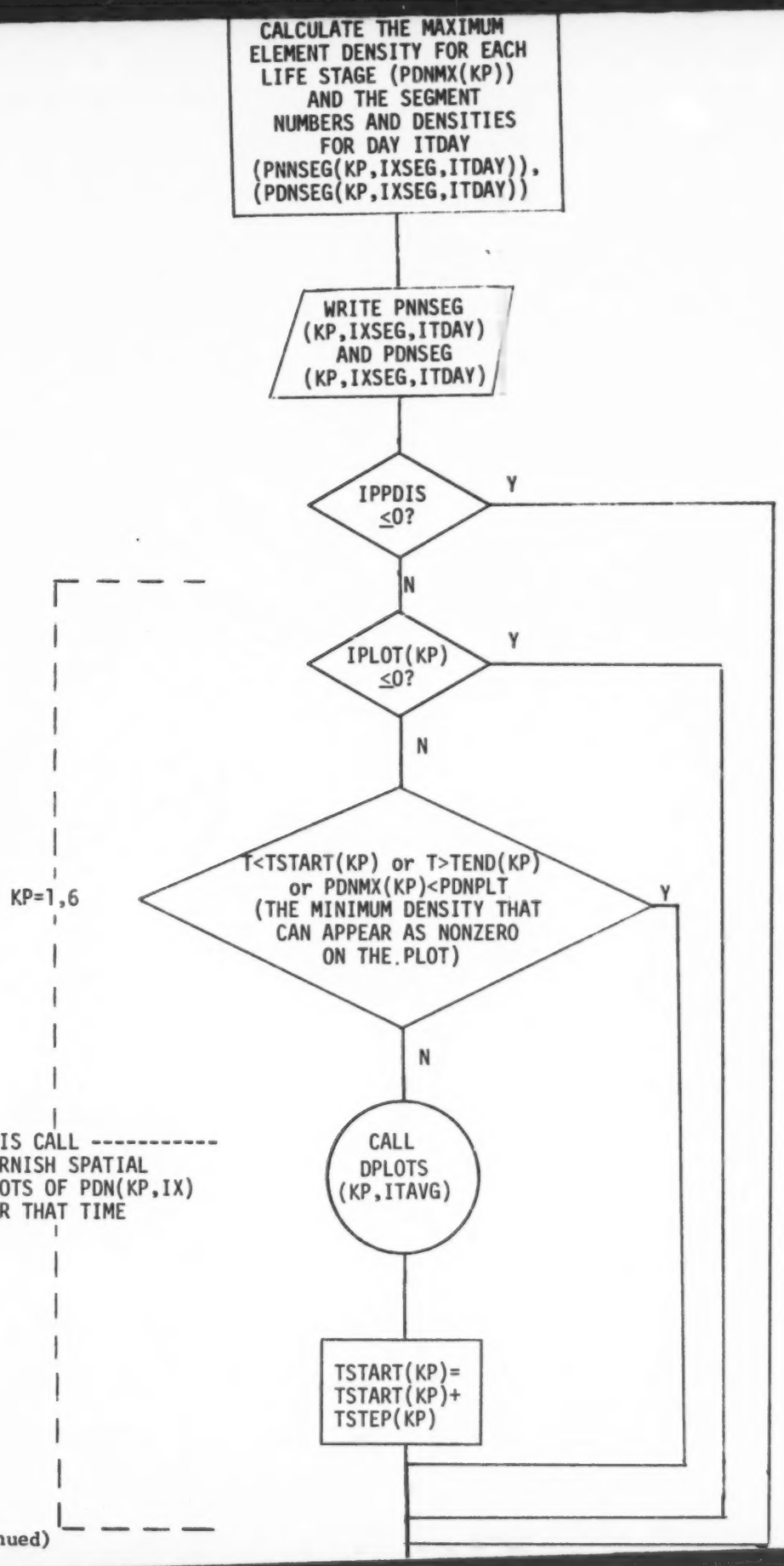
CALCULATE THE MAXIMUM ELEMENT DENSITY FOR EACH LIFE STAGE (PDNMX(KP)) AND THE SEGMENT NUMBERS AND DENSITIES FOR DAY ITDAY (PNNSEG(KP,IXSEG,ITDAY)), (PDNSEG(KP,IXSEG,ITDAY))
WRITE PNNSEG (KP,IXSEG,ITDAY) AND PDNSEG (KP,IXSEG,ITDAY)
IPPDIS ≤0?
Y
N
IPLOT(KP) ≤0?
Y
N
KP=1,6
T<TSTART(KP) or T>TEND(KP) or PDNMX(KP)<PDNPLT (THE MINIMUM DENSITY THAT CAN APPEAR AS NONZERO ON THE PLOT)
Y
N
THIS CALL ---------- FURNISH SPATIAL PLOTS OF PDN(KP,IX) FOR THAT TIME
CALL DPLOTS (KP,ITAVG)
TSTART(KP)= TSTART(KP)+ TSTEP(KP)

Fig. B.1 (continued)

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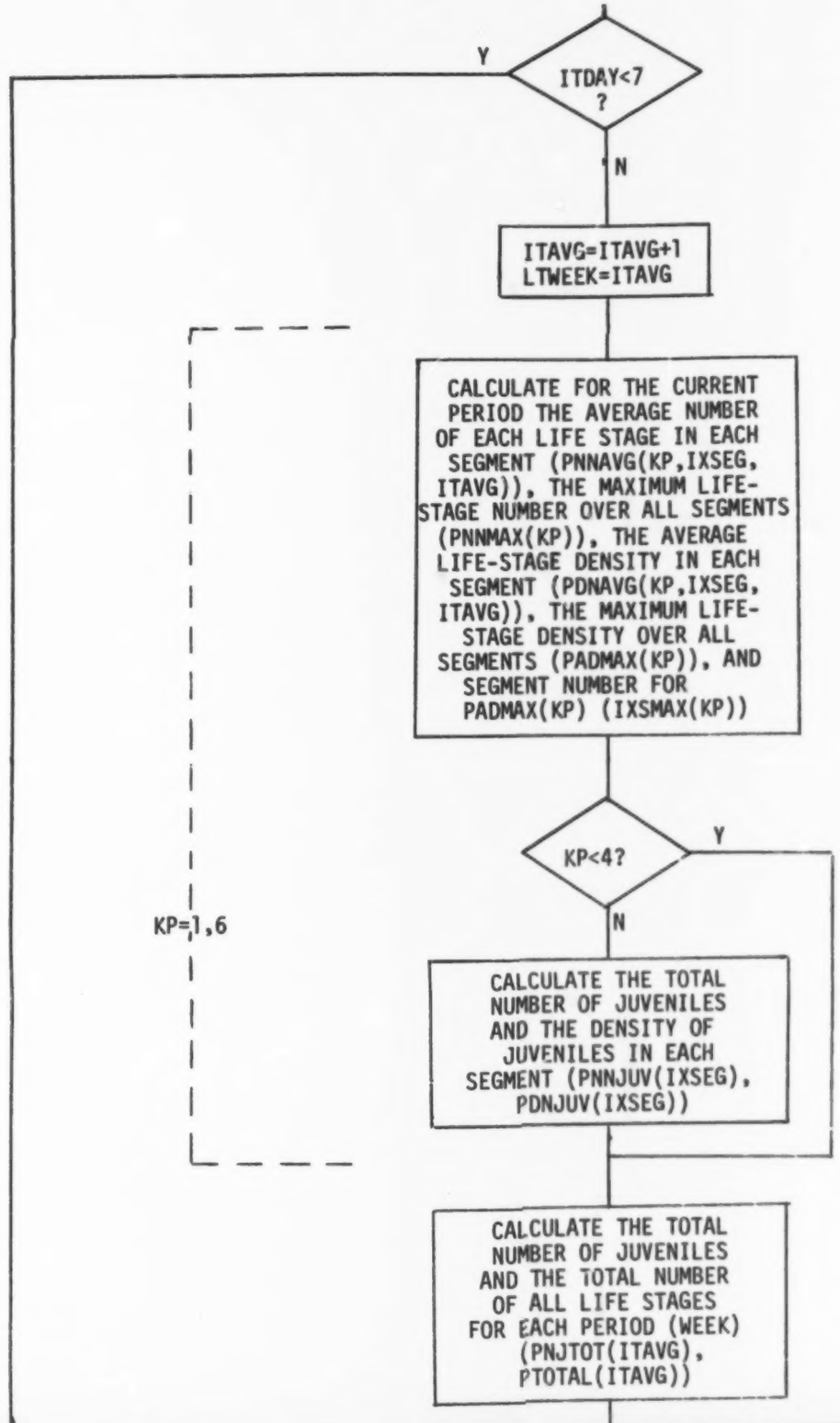
ITDAY<7 ?
Y
N
ITAVG=ITAVG+1
LTWEEK=ITAVG
CALCULATE FOR THE CURRENT PERIOD THE AVERAGE NUMBER OF EACH LIFE STAGE IN EACH SEGMENT (PNNAVG(KP,IXSEG, ITAVG)), THE MAXIMUM LIFE-STAGE NUMBER OVER ALL SEGMENTS (PNNMAX(KP)), THE AVERAGE LIFE-STAGE DENSITY IN EACH SEGMENT (PDNAVG(KP,IXSEG, ITAVG)), THE MAXIMUM LIFE-STAGE DENSITY OVER ALL SEGMENTS (PADMAX(KP)), AND SEGMENT NUMBER FOR PADMAX(KP) (IXSMAX(KP))
KP<4?
Y
N
KP=1,6
CALCULATE THE TOTAL NUMBER OF JUVENILES AND THE DENSITY OF JUVENILES IN EACH SEGMENT (PNNJUV(IXSEG), PDNJUV(IXSEG))
CALCULATE THE TOTAL NUMBER OF JUVENILES AND THE TOTAL NUMBER OF ALL LIFE STAGES FOR EACH PERIOD (WEEK) (PNJTOT(ITAVG), PTOTAL(ITAVG))

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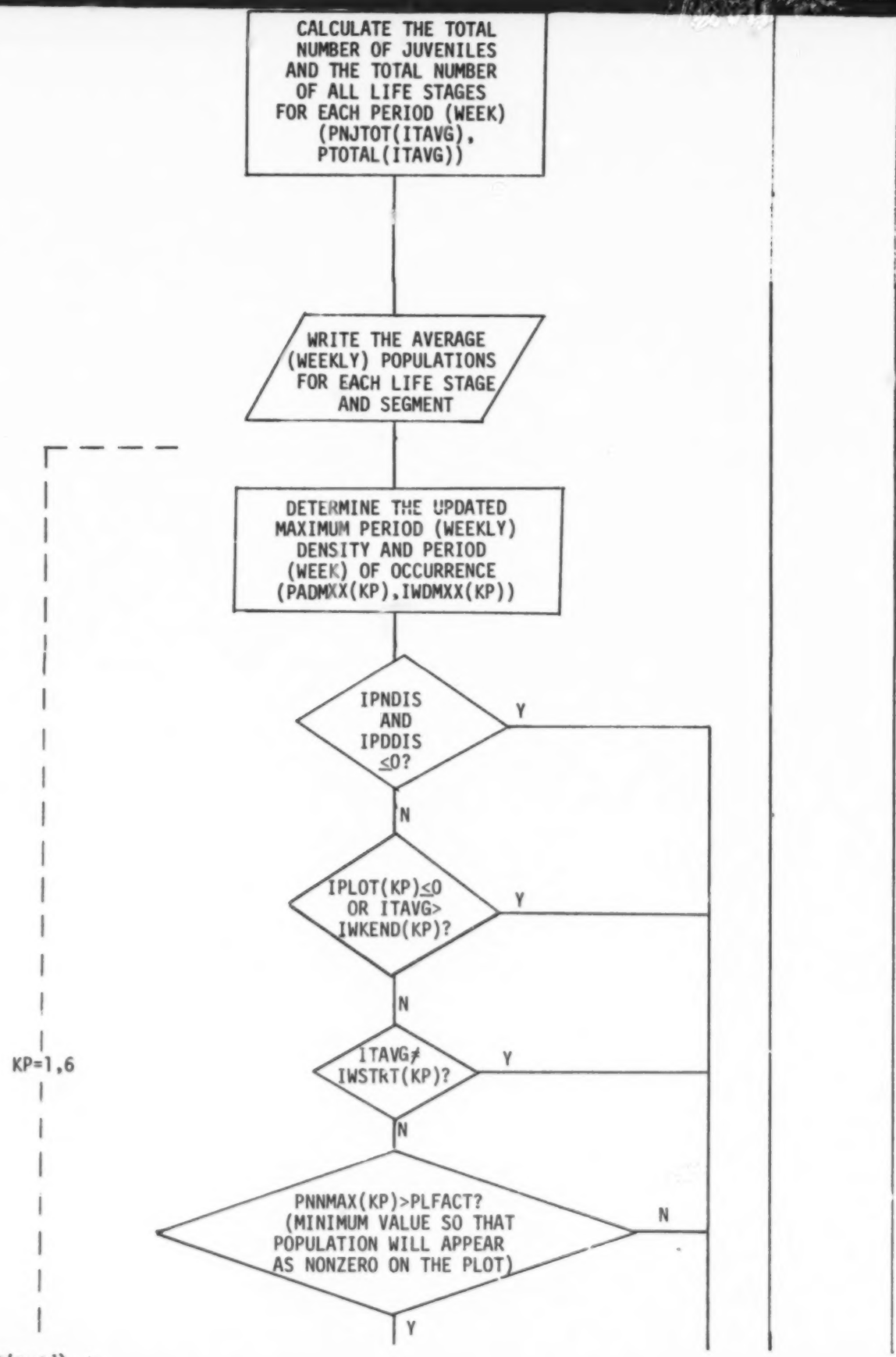
CALCULATE THE TOTAL NUMBER OF JUVENILES AND THE TOTAL NUMBER OF ALL LIFE STAGES FOR EACH PERIOD (WEEK) (PNJTOT(ITAVG), PTOTAL(ITAVG))
WRITE THE AVERAGE (WEEKLY) POPULATIONS FOR EACH LIFE STAGE AND SEGMENT
DETERMINE THE UPDATED MAXIMUM PERIOD (WEEKLY) DENSITY AND PERIOD (WEEK) OF OCCURRENCE (PADMXX(KP),IWDMXX(KP))
IPNDIS AND IPDDIS ≤0?
Y
N
IPLOT(KP)≤0 OR ITAVG> IWKEND(KP)?
Y
N
ITAVG≠ IWSTRT(KP)?
Y
N
PNNMAX(KP)>PLFACT? (MINIMUM VALUE SO THAT POPULATION WILL APPEAR AS NONZERO ON THE PLOT)
N
Y
KP=1,6

Fig. B.1 (continued)

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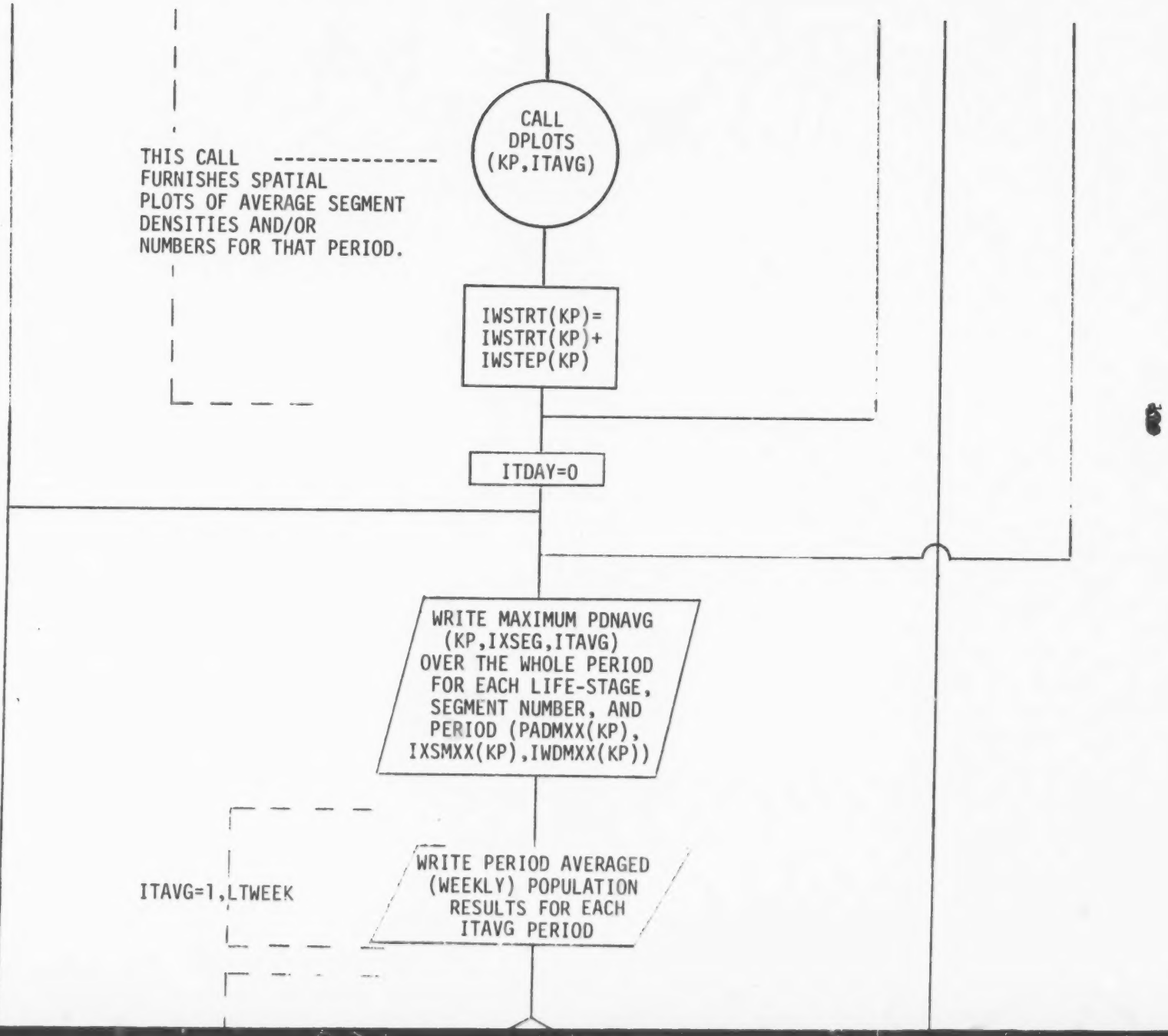
CALL DPLOTS (KP,ITAVG)
THIS CALL FURNISHES SPATIAL PLOTS OF AVERAGE SEGMENT DENSITIES AND/OR NUMBERS FOR THAT PERIOD.
IWSTRT(KP)= IWSTRT(KP)+ IWSTEP(KP)
ITDAY=0
WRITE MAXIMUM PDNAVG (KP,IXSEG,ITAVG) OVER THE WHOLE PERIOD FOR EACH LIFE-STAGE, SEGMENT NUMBER, AND PERIOD (PADMXX(KP), IXSMXX(KP),IWDMXX(KP))
ITAVG=1,LTWEEK
WRITE PERIOD AVERAGED (WEEKLY) POPULATION RESULTS FOR EACH ITAVG PERIOD

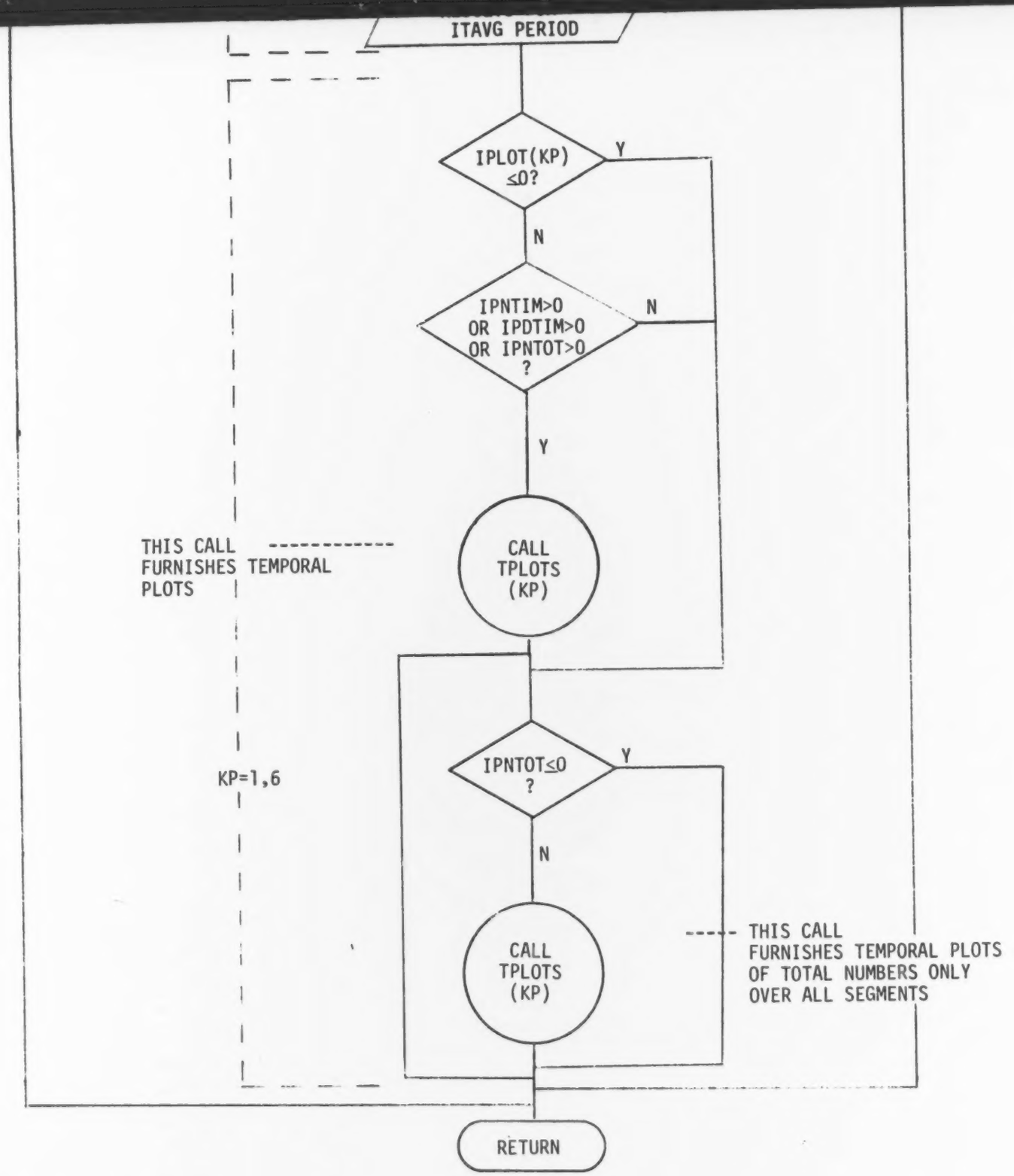

Fig. B.1 (concluded)

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TABLE B.1

Description of the Fifteen Averaged River Segments Used in STORER

IXSEG	Contains Elements	Location of Center of Segment in Miles from the Battery
1	2 - 6	-145
2	7 - 11	-135
3	12 - 16	-125
4	17 - 21	-115
5	22 - 26	-105
6	27 - 31	-95
7	32 - 36	-85
8	37 - 41	-75
9	42 - 46	-65
10	47 - 51	-55
11	52 - 56	-45
12	27 - 61	-35
13	62 - 66	-25
14	67 - 71	-15
15	72 - 76	-5

In addition, STORER calculates the total number for each life stage, total juveniles, and sum total of all life stages in all segments for each period (ITAVG), and determines the magnitude and time of the maximum average segment density for each life stage in the computational phase (KRUN = 1). These results are not written, however, until the special output phase (KRUN = 2). STORER then calls subroutine TPLOTS (KRUN = 2) if any type of temporal plot is requested. See Tables C.9 - C.11 for sample output from subroutine STORER.

DPLOTS

If any of IPDIST, IPNDIS, or IPDDIS is greater than 0, STORER reads additional variables that control the types of plots from subroutine DPLOTS. These varibles are read on logical unit 1 to separate them from other input. STORE initially reads IPLOT(KP) for each life stage (KP), which indicates whether life stage KP is plotted. Table B.2 shows when the additional plot variables are read in DPLOTS and describes their function.

There are eight possible combinations of the three output flags used in DPLOTS -- IPDIST, IPPDIS, and IPNDIS. Subroutine DPLOTS is not called if all three flags are zero (Case 0), however, so there are no spatial plots in that case. Table B.3 shows the possible plot possibilities from DPLOTS. For Case 4, PDN(KP,IX) for life stage KP is plotted against miles from the Battery if IPLOT(KP) is greater than 0, the maximum PDN(KP,IX) for KP at any of the discrete elements (PDMX(KP)) is greater than PDNPLT, and TSTART(KP) T TEND(KP). PDNPLT equals PDNMAX/ 50.0, where PDNMAX (the ordinate maximum of the plots) is an approximation of the maximum density of all the life stages. The closer that PDNMAX is to the actual maximum

density of all the life stages, the more nonzero data points will appear on the plot. SCAFCT is a scale factor for the population densities. SCAFCT is increased by 10 for KP = 4 to 6 because these age-group populations are less dense.

For all the cases, STORER makes five-element-averaged population calculations. These results are written and plotted if IPLOTS(KP) is greater than 0 and PNMAX(KP) is greater than PLFACT. PLFACT equals PNMX/ 50.0, where PNMX is the estimated maximum number for all life stages in the estuary at any time. PNNMAX(KP) is the maximum five-element-averaged number for that ITAVG (week). SCALE1 and SCALE2 are used to scale PNNAVG and PDNAVG plots, respectively. Plots from the sample case from DPLOTS are shown in Appendix C. All plots from DPLOTS are selected populations against miles from the Battery. Figure C.1(IPDIST > 0) shows egg life-stage density at T = 672.0 hours. Figure C.2 (IPNDIS > 0) shows the five-element averaged number of eggs during week 4. Figure C.3 (IPDDIS > 0) shows the five-element-averaged egg density during week 4. Figures C.1-C.3 may be made for every life stage if certain plot conditions are met. Table B.4 shows the input read on logical unit 1 for the sample spatial plots from DPLOTS.

TPLOTS

Subroutine TPLOTS is called in the KRUN = 3 phase of subroutine STORER if any of IPDTIM, IPNTIM, or IPNTOT is greater than 0. If IPDTIM or IPNTIM is greater than 0, the total number of segments for temporal plots and the indices of the segments are read on logical unit 2. Table B.5 describes the plot possibilities from TPLOTS.

Sample case plots from TPLOTS are shown after this description of each plot. All printer plots from TPLOTS are averaged (weekly) populations plotted against the (week) ITAVG number from the start of eggs in segment 10. Figure C.4 (IPNTIM > 0) shows the number of eggs in segment 10. Figure C.5 (IPDTIM > 0) shows the egg density in segment 10. IPNTOT is greater than 0 for plots C.1-C.13. Figure C.6 is the total number of eggs in all segments. Figure C.7 is the total number of yolk sacs in all segments. Figure C.8 is the total number of larvae in all segments. Figure C.9 is the total number of juvenile I in all segments. Figure C.10 is the total number of juvenile II in all segments. Figure C.11 is the total number of juvenile III in all segments. Figure C.12 is the total number of juveniles in all segments, and Figure C.13 is the total number of all life stages in all segments. Figures like C.1-C.5 may be given for every life stage if the certain plot conditions are met. Table B.4 shows the input read on logical unit 2 for the sample temporal plots.

NOTE: The printer plot subroutines can use a LOGICAL*1 declaration for the plot array A and any of the plot symbols if that declaration is supported. All the LOGICAL*1 declarations are presently comments, however, so that the default word size is used. In addition, if any of the populations to be plotted fall outside of the plot range, an A will be placed at the top axis of the plot to denote that the population is above the plot maximum or a B will be placed on the bottom axis to denote the population is below the plot minimum.

TABLE B.2

Additional Plot Variables Read in DPLOTS and Description of Their Function

Condition	Variable Name	Definition of Variable
IPDIST > 0	ISTART(KP)	the starting time limit (hrs) for PDN (KP,IX) plots
	TEND (KP)	the final time limit (hrs) for PDN(KP, IX plots
	TSTEP(KP)	the time step (hrs) between PDN(KP,IX) plots
IPDDIS and/or > 0 IPNDIS	IWSTRT(KP)	the first ITAVG period (week) for PDNAVG (KP,IXSEG,ITAVG) and/or PNNAVG(KP,IXSEG, ITAVG) plots
	IWDENK(KP)	the last ITAVG limit (week) for PDNAVK (KP,IXSEG,ITAVG) and/or PNNAVG(KP,IXSEG, ITAVG) plots
	IWSTEP(KP)	the time step, number of ITAVG periods (weeks) between PDNAVG(KP,IXSEG,ITAVG) and for PNNAVG(KP,IXSEG,ITAVG) plots

TABLE B.3

Possible Plot Possibilities from DPLOTS

	Cases							
	0	1	2	3	4	5	6	7
IPDIST	0	0	0	0	1	1	1	1
IPDDIS	0	1	1	0	0	0	1	1
IPNDIX	0	1	0	1	0	1	0	1

Case 0 - Five-element-averaged population calculations are made and results are written in STORER.

Case 1 - Five-element-averaged population calculations are made and results are written in STORER; PDNAVG and PNNAVG plots are made for life stage KP if IPLOT(KP) > 0 and IWSTRT(KP) ITAVG IWEND(KP).

Case 2 - Five-element-averaged population calculations are made and results are written in STORER; PDNAVG plots are made for life stage KP if IPLOT(KP) > 0 and IWSTRT(KP) ITAVG IWEKEND(KP).

Case 3 - Five-element-averaged population calculations are made and results are written in STORER; PNNAVG plots are made for life stage KP if IPLOT(KP) > 0 and IWSTRT(KP) ITAVG IWKEND(KP).

Case 4 - Five-element-averaged population calculations are made and results are written in STORER; PDN plots for life stage KP are made every time OUTPUT is called by the main program if IPLOT(KP) > 0 and TSTART(KP T TEND(KP).

Case 5 - Same as Case 3, but with PDN plots of Case 4.

Case 6 - Same as Case 2, but with PDN plots of Case 4.

Case 7 - Same as Case 1, but with PDN plots of Case 4.

TABLE B.4

Input Read on Logical Unit 1 for the Sample Spatial Plots and on Logical Unit 2 for the Sample Temporal Plots from DPLOTS

```
//GO.FT01F001 DD *                                  IPLOT(KP)
   1   0   0   0   0   0   0                      TSTART(1),TEND(1),TSTEP(1)
671.9          672.1          0.0                IWSTRT(1),IWKEND(1),IWSTEP(1)
   4   4   1
//GO.FT02F001 DD *                               NSGMTS,(IPLOTX(IS),IS=1,NSGMTS)
   1  10
```

TABLE B.5

Plot Possibilities from TPLOTS

	Cases							
	0	1	2	3	4	5	6	7
IPNTIM	0	0	0	0	1	1	1	1
IPDTIM	0	0	1	1	0	0	1	1
IPNTOT	0	1	0	1	0	1	0	1

Case 0 - Five-element population averages over the whole time period are written in STORER.

Case 1 - Five-element population averages over the whole time period are written in STORER; the total number of each life stage, KP, for each ITAVG period is plotted against the whole time period, the total number of juveniles for each ITAVG is plotted against the whole time period, and the sum total of all life stages for each ITAVG is plotted against the whole time period.

Case 2 - Five-element population averages for the whole time period are written in STORER; average five-element densities for each ITAVG (week) are plotted against the whole time period for specified segments, if IPLOT(KP) is greater than 0.

Case 3 - Five-element population averages densities for each ITAVG for the whole time period are written in STORER; plots as from Cases 1 and 2 are given.

Case 4 - Five-element population averages over the whole time period are written in STORER; the five-element-averaged number of each life stage, KP, for each ITAVG is plotted against the whole time period for specified segments if IPLOT(KP) is greater than 0.

Case 5 - Five-element population averages over the whole time period are written in STORE; plots as from Cases 1 and 4 are given.

Case 6 - Five-element population averages over the whole time period are written in STORER; plots as from 2 and 4 are given.

Case 7 - Five-element population averages over the whole time period are written in STORER; plots as from 1, 2, and 4 are given.

Microfiche of Listings for

Additional Output Subroutines

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APPENDIX C. SAMPLE CASE INPUT AND OUTPUT

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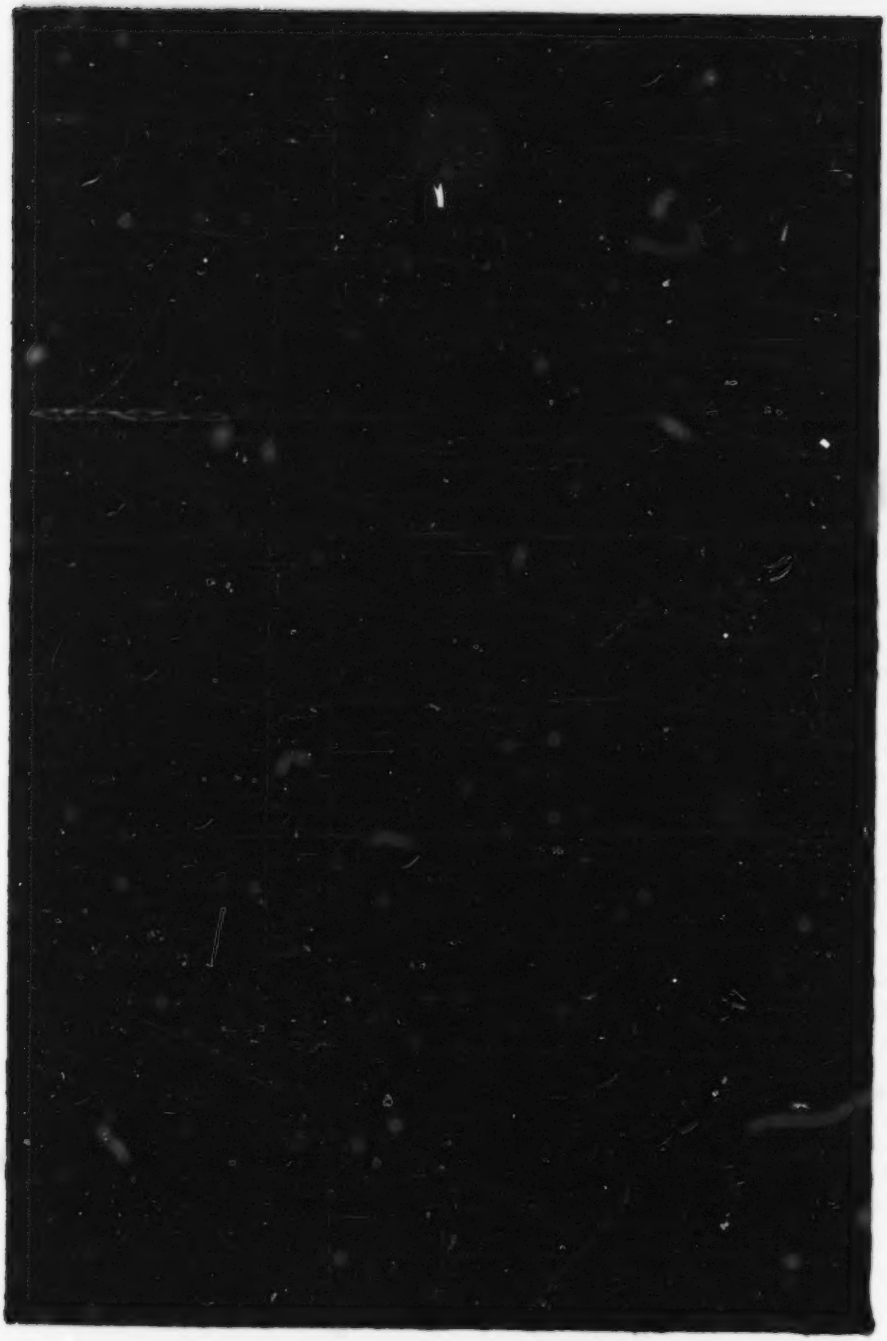
Data Input for Sample Case



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